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EXTERNAL RESPIRATION, GAS EXCHANGE AND ENERGY EXPENDITURES OF MAN IN WEIGHTLESSNESS

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 6, Nov-Dec 84 (manuscript received 27 Jun 83) pp 4-9

[Article by I. I. Kas'yan and G. F. Makarov]

[English abstract from source] This paper summarizes the data on external respiration and energy expenditures of men exposed to zero-g for 185 days and to 1/6 g on the lunar surface reported by Soviet and foreign authors. The paper also discusses factors that may be responsible for a higher level of gas exchange processes at reduced g.

[Text] We summarize here the results of studies of functional state of external respiration, gas exchange and amount of energy expended by man in weightlessness, which were obtained during orbital flights of different duration (spacecraft of the Vostok, Voskhod and Soyuz types, and the Salyut orbital station). In addition, we used the data of foreign researchers, which they obtained during missions of Gemini and Apolto spacecraft, and the Skylab orbital station.

In order to compare results obtained by different researchers, volumetric parameters of external respiration (pulmonary ventilation, vital capacity of the lungs) were scaled to BTPS conditions, while those for gas exchange (minute respiratory volume and oxygen uptake) and energy expended were scaled to STPD conditions.* For the same purpose, energy expenditures are given here in both kilojoules and kilocalories.

Respiration rate measured in cosmonauts aboard Vostok, Voskhod, Soyuz and orbital stations of the Salyut type in the period of lift-off minus 4 h and -5 min was higher than the base rate, which was apparently related to prelaunch nervous and mental excitement [7].

After the craft was inserted in orbit, resting respiratory rate continued to rise in most cosmonauts. Thereafter (first 5 days of flight) it gradually declined and became stabilized at the initial (prelaunch) level [5,7]. However, some cosmonauts had a higher respiratory rate than the base level at all stages of flight. The difference in respiratory reactions of cosmonauts is apparently

*BTPS and STPD--international standard conditions.

attributable to individual distinctions of adaptation to weightlessness. The changes in respiration were associated also with more marked cardiovascular reaction, as well as slower postflight recovery of respiration and pulse [7].

During the longer missions (up to 185 days), respiratory rate of cosmonauts at relative rest continued to be above the level observed in man on earth for the duration of the flight [5].

Analysis of response of respiratory rate to graded physical exercise both during short and long-term flights revealed that it was higher than during performance of the same exercise before the flight [3, 7]. However, it was found that there was a tendency toward normalization of respiration during the same exercise load, when exercises were performed regularly (on a bicycle ergometer) during long-term missions [6].

Vital capacity. Our testing of vital capacity (VC) in weightlessness revealed that it changed dissimilarly in the period of acute adaptation: in some cosmonauts we observed an increase and in others, a decrease of this parameter, as compared to preflight values. The changes were minor, as can be seen from the results of studies performed by crew members of Soyuz-5, Soyuz-6 and Soyuz-7 [7], as well as Salyut-3, 4, 5 and 6 stations. Thus, at rest, VC ranged from 4348±224 to 4569±159 mℓ, and after exercise the range was from 4458±326 to 4609±169 mℓ [6, 7].

According to the data of American researchers [17], VC was lower in weightlessness than on the ground and, in the opinion of the authors, this is due to the effects of several factors: low ambient atmospheric pressure, shifting of body fluids to upper half of the body and of the diaphragm into the chest.

Thus, VC changes in man at zero gravity were in different directions and insignificant in magnitude.

In the postflight period, vital capacity of the cosmonauts returned to normal within 24 h [9].

Pulmonary ventilation. The studies performed by the crews of Voskhod, Soyuz and Salyut revealed that pulmonary ventilation (PV) at relative rest increased to 34% in the acute period of adaptation, as compared to prelaunch values [3, 7]. During long-term flights, there was less increase in PV than in the period of acute adaptation to zero gravity [6].

Analogous findings were made during missions of Skylab-2, Skylab-3 and Skylab-4 orbital stations [18-20]. Resting PV was higher throughout the flights in 7 out of 9 astronauts than under ground-based conditions.

External respiratory reaction to graded exercise performed during the first 5 days of flight was more marked than observed preflight [7].

But with increase in duration of weightlessness, PV diminished in response to exercise, although it continued to be greater than on the ground [6].

Studies conducted during the 84-day mission aboard the Skylab-4 orbital station [17, 21] revealed that the PV changes during exercise (on bicycle ergometer) constituting 70% of maximum aerobic rate were dissimilar in magnitude and

direction: more marked increase in PV in response to physical load was observed in some astronauts, while in others the increase was less marked than during performance of the same exercise on the ground.

Energy expenditure. During missions aboard Voskhod, Soyuz spacecraft and the Salyut-9 orbital station, energy expended by all cosmonauts in a state of relative rest was greater than on the ground. During missions lasting up to 5 days, it increased by a mean of 2.64 kJ/min (0.63 kcal/min), the range being from +4.86 to +0.38 kJ/min (+1.16 to +0.09 kcal/min) [6, 7].

Analogous findings were made by American researchers [17]. It should be noted that there were individual distinctions and fluctuations of energy expended by man at rest in weightlessness [6]. Thus, oxygen uptake and energy expenditure were 19.0% greater in some of the Skylab-4 astronauts and only 7.8% greater in others [16].

The results of studies of reactions to graded physical loads revealed that the energy expenditure was greater in the period of acute adaptation to weightlessness than during performance of the same exercise before the flight [6, 7].

We were impressed by the fact that in missions lasting 14 days or more there was slower recovery after exercise, which is an indication of appearance of "oxygen debt" in the body. Indeed, in ground-based experiments the recovery period lasted no more than 5 min.

With increase in duration of exposure to weightlessness, there was both increase and decrease in energy expenditure during a physical load. While energy expenditure for one cosmonaut aboard the Salyut-4 orbital station, when measured immediately after a graded load (on bicycle ergometer), increased from 9.34 kJ/min (38th flight day) to 9.80 kJ/min (54th flight day), in another cosmonaut energy expenditure measured on the same days decreased from 13.11 to 11.51 kJ/min.

A difference in dynamics of energy expended during exercise performed in weightlessness (ergometer) was also found during the 84-day mission aboard Skylab-4 [17, 21]. Thus, the scientist-pilot showed a 2% greater energy expenditure during pedaling on the bicycle ergometer (average of 12 measurements) than when performing equal exercise on the ground, whereas for the other two astronauts it was 2.0 and 8.5% lower.

Analysis of the data obtained during the Skylab-4 mission revealed that there was a longer recovery period after the physical load. Thus, in 2 astronauts of Skylab-4, energy expenditure was 3.4 and 11.0% greater during a 5-min recovery period after exercise than in the same period on the ground, whereas in another it was smaller than the values obtained preflight.

External respiration and energy expenditure during extravehicular activity. The results of tests performed during man's first extravehicular activity in a spacesuit [7] revealed that the respiration rate of A. A. Leonov (Voskhod-2) reached 26-36/min (versus 10-15 min under ordinary conditions on earth) and pulse rate was 152-162/min.

Respiration rate averaged 27/min for Ye. V. Khrunov (Soyuz-5) during preparations for transfer to Soyuz-4 spacecraft and 36/min during the transfer. Maximum respiration rate for this cosmonaut was 49/min during the transfer [7].

It should be stressed that neither A. A. Leonov nor Ye. V. Khrunov had been in actually unsupported position: presence of a tether facilitated to some extent performance of the necessary work operations. Extravehicular activity without the tether was associated with considerably more effort and time for performance of various operations than had been expected on the basis of experiments. The Gemini-9 and Gemini-10 astronauts presented not only high respiration and heart rates, but profuse perspiration, excessive accumulation of heat and signs of fatigue during space walks with use of jet-propulsion devices (to move about), and as a result it was necessary to modify the previously planned operations or cancel them. Thus, in the opinion of E. Cernan (Gemini-9), performance of operations in space required 4-5 times more exertion than on earth, and he was unable to perform part of the planned program because the glasses in his pressure helmet had steamed up. E. Cernan's pulse was 130-170/min during extravehicular activity, while energy expenditure exceeded 2093 kJ/h (500 kcal/h) [11].

When Astronaut M. Collins (Gemini-10) walked in space, his respiration rate rose to 36/min and pulse to 160/min; as a result, duration of his extravehicular activity was reduced due to development of fatigue. The space walk of R. Gordon (Gemini-11) was curtailed due to severe perspiration and overheating. His respiration rate rose to 36-40/min during extravehicular activity and perspiration exceeded the nominal level (2094 kJ/h). Although energy expended by the astronauts was not measured directly, it was apparent that heat production was greater during space walks than the efficiency of the space suit cooling systems (as estimated from ground-based experiments), while energy expenditure of the astronauts constituted up to 3600 kJ/h (860 kcal/h) at different stages of extravehicular activity [12, 13].

With refinement of the design of space suits there was decrease in changes referable to the cardiorespiratory system and energy expenditure [16, 19, 20]. Thus, energy expenditure constituted a mean of about 963 kJ/h (230 kcal/h) during space walks of Skylab astronauts. Mean level of energy expenditure ranged from 1086 to 1381 kJ/h (260-330 kcal/h) for the first Skylab crew, 754 to 1298 kJ/h (180-310 kcal/h) for the second crew and 607 to 1074 kJ/h (145-250 kcal/h) for the third crew. The highest level, 2094 kJ/h (500 kcal/h) was recorded for the commander of the first crew, when he tried to cut a bracing that was in the way for installaing solar batteries [20].

Analogous data on reactions of the respiratory system and energy expenditure were obtained for cosmonauts V. A. Lyakhov and V. V. Ryumin (Soyuz-32--Salyut-6 orbital complex) who walked in space on the 172d day of exposure to orbital weightlessness. Thus, during extravehicular activity the crew commander's respiration rate constituted a mean of 21/min, with a range of 16 to 28/min; the flight engineer's respiration rate ranged from 18 to 26/min while working in open space (moving over a distance of 28 m in his space suit, using hand rails, and disconnecting the radiotelescope antenna).

Energy expended by astronauts while on the moon. It had been expected (on the basis of theoretical estimates and results of simulations on the

ground) that energy expenditure would be the most economical, as compared to ground-based conditions, when walking on the moon, whereas it would be greater for other forms of activity. In essence, these expectations were confirmed during the lunar expeditions of the crews of the Apollo spacecraft.

Energy expenditure constituted an average of 964-1256 kJ/h (226-300 kcal/h), reaching more than 2512 kJ/h (600 kcal/h) at some times, when the commander and pilot of the lunar module of Apollo-11 walked on the moon [11, 12]. These levels are about the same as when walking on earth at the rate of 5 km/h without using any gear or when moving in a space suit at the rate of 1 km/h. While walking on the moon, heat production constituted 2366 kJ (565 kcal) for one astronaut and 3195 kJ (763 kcal) for the other. The average walking rate over a distance of 2.9 km on the moon constituted 2.4 km/h with energy expenditure of about 1256 kJ/h (300 kcal/h). Maximum energy expenditure (1465-1884 kJ/h) was related to performance of discrete operations: walking up steep inclines, carrying and installing scientific equipment, drilling. A lower metabolic rate was recorded while driving the lunar excursion module.

Generalization of the results of testing external respiration, gas exchange and human energy expenditure during spaceflights lasting up to 185 days revealed that the intensity of gas-exchange processes measured both in a state of relative rest and during performance of graded physical exercise (in most cases) became stabilized at a higher level in weightlessness than on earth.

The causes of these changes have not yet been sufficiently explored, and their mechanism is still unclear in many respects.

It should be assumed that the increased intensity of gas-exchange processes in the period of acute adaptation to weightlessness is attributable to nervous-emotional and mental tension that appears under the effect of spaceflight factors and the space environment.

It is known that, with exposure to stress factors, heart and respiration rates are the first to increase, and this leads to increased expenditure of energy. The results of basic research on the physiology of work processes and external respiratory function [4] revealed that a change in only the respiration rate with retention of unchanged pulmonary ventilation could elicit a 10% increase in basal metabolic rate, since the function of respiratory muscles requires additional use of oxygen. As for oxygen use with increased pulmonary ventilation, in the opinion of the same authors [4], change in this parameter depends on several causes, in particular, the functional state of the cerebral cortex, and it ranges from 3.3 to 11.3 mℓ/ℓ excess ventilation. The presence of excess ventilation per se increases oxygen uptake and, consequently, basal metabolic rate also. For this reason, the higher level of pulmonary ventilation, which was observed in cosmonauts during flights in a state of relative rest causes a higher level of energy expenditure at rest than on earth.

The changes that occur in organs and systems during adaptation to new physical living conditions should be considered other causes of higher energy expenditure of man in weightlessness. They include impairment of coordination structure of movements, overafferentation of all sensory systems, changes related to redistribution of blood and relatively excessive amounts of blood in the upper half

of the body, as well as functional changes in the central nervous system as a result of the above-mentioned changes.

It is known that well-developed movements during performance of customary work are the most economical with regard to energy expenditure [2]. Any impairment of the structure of movements related to novelty of work, change in working conditions, change in the neuromuscular system or its central regulatory mechanisms leads to increased expenditure of energy.

Discoordination of movements due to change in physical factors (absence of body weight in weightlessness, change in first and second derivatives of motion--velocity and acceleration) leads to increase in energy cost of both static (maintaining a specific position of the body and limbs in space) and dynamic (performance of movements) work.

Wagner reports on increased tension of postural muscles in weightlessness [21], on the basis of analysis of complaints by the American astronauts, W. Schirra, W. Cunningham and J.Lovell (Apollo-7) of pain in muscles of the back (costovertebral articulations) which developed, in the astronauts' opinion, due to the need to constantly maintain the body and limbs in an unusual position in unsupported space, even at relative rest. It is remarkable that this pain disappeared after exercising.

Elimination of hydrostatic blood pressure and redistribution of body fluids in weightlessness to the upper part of the body alter appreciably pulmonary circulating, eliciting stasis in the lungs and cerebral vessels. We know from clinical observations of patients with functional circulatory insufficiency (particularly when combined with pulmonary circulatory insufficiency)[4] that basal metabolic rate is elevated in 90% of such patients, and the increase constituted 20 to 38%. For this reason, theoretically we cannot rule out the possibility that the increased energy expenditure at rest in weightlessness is due to redistribution of blood and functional insufficiency of the cardiovascular and respiratory systems.

We should mention another factor that affects metabolic processes in weightlessness. The difficulties of gas exchange in the lungs due to stasis in them and vessels in the pulmonary circulatory system diminish the efficiency of pulmonary ventilation with unchanging oxygen requirement of the body. Evidently, this is the cause of increased pulmonary ventilation in weightlessness which, in turn, leads to increased energy expenditure at rest.

The results of testing respiratory system function during spaceflight in the acute period of adaptation to weightlessness revealed that, when exercising on a bicycle ergometer there was more marked (than on earth) increase in respiration rate with concurrent decline of respiratory volumes [3]. This, in turn, leads to increased expenditure of energy for respiration [2, 4] and elevated level of energy expenditure in weightlessness.

The increase in energy expenditure in weightlessness could also be due to structural changes in muscle tissue. It has been established [8] that the force properties of a number of muscle groups diminished by 30% after exposure to weightlessness (as well as after immersion). This led to significant

increase in electromyographic cost of muscular exertions. The studies of several authors [8, 10] established that there is change in bioenergetics of muscles and tissues in the direction of quantitative and qualitative shift of oxidative processes with intensification of glycolytic route of energy synthesis. This is indicative of inadequate delivery of oxygen to tissues, apparently due to impaired diffusion of oxygen through the alveoli. Accumulation of products of glycolysis, as well as intracellular acidosis, which develops as a result of adaptive changes, lead to increase in oxygen debt and accumulation of lactic acid which, in the opinion of a number of authors [4, 15], increases ventilation and basal metabolism.

The influence of intensive exercise performed by cosmonauts to prevent deconditioning on the ground could be a substantial cause of higher level of metabolic processes in weightlessness.

The increase in work-related energy expenditure of cosmonauts in weightlessness could also be due to the constant use of special weighted gear which creates some load on the skeletomuscular system along the vertical axis of the body; in addition, it generates some force through cushioning devices, which the cosmonauts must overcome when moving the trunk and limbs over all axes of the body.

R. M. Bayevskiy [1], who analyzed the ECG of crew members aboard the Salyut-6 orbital station, who exercised on the onboard bicycle ergometer, arrived at the conclusion that the body's adaptation to long-term flight is associated with changes in regulatory systems, and authors consider the increase in "tension index" to be among the adverse changes; in their opinion this index reflects an increase in "price" of the body's adaptation to a load in weightlessness as a result of mobilization of energy and metabolic resources during adaptation.

One should also bear in mind that, with increase in duration of flights, there will also be increase in cosmonauts' fatigue which, as we know [2], increases the share of energy expenditure per unit work performed. The build-up of oxygen debt after cosmonauts perform graded exercise is indicative of manifestation of signs of fatigue with increase in duration of missions.

The data available at the present time concerning external respiration, gas exchange and energy expenditures do not enable us to conclude that processes of adaptation to weightlessness had been completed in the course of the 185-day orbital flight and that metabolic processes became established at a given level. Systematic investigation of gas exchange and energy metabolism must be continued during future spaceflights.

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EXPERIMENTAL AND GENERAL THEORETICAL RESEARCH

UDC: 629.78:616.153.466-07

BLOOD AMINO ACIDS OF COSMONAUTS BEFORE AND AFTER 211-DAY SPACEFLIGHT

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 6, Nov-Dec 84 (manuscript received 12 Aug 83) pp 10-15

[Article by I. G. Popov and A. A. Latskevich]

[English abstract from source] The plasma content of 17 free amino acids of the Commander and Flight-Engineer of Salyut-1-Soyuz-T was examined before flight and on postflight days 1 and 7. The amino acids were measured in an automatic amino acid analyzer Hitachi KLA-3B. Both cosmonauts showed a decrease of most amino acids, particularly essential amino acids. On postflight day 7 the content of most amino acids did not yet return to the preflight level. It can therefore be concluded that the preflight diet should be supplemented with methionine and aspartic acid, and the flight and postflight diets with 7 essential amino acids plus cystine, arginine, proline and aspartic acid.

[Text] Long-term missions in orbital research stations make high demands of cosmonauts, including various aspects of metabolism. Along with metabolic changes due to processes of adaptation to the set of spaceflight factors, there may be some changes due to accumulation of adverse effects of flight factors. In particular, when there is a shortage of some nutrients in foods or their absorption in the intestine and utilization on the cellular level are impaired, there could be gradual development of a chronic deficiency of these nutrients with the attending adverse consequences to metabolism and various physiological processes. In view of the important role of amino acids in anabolic and catabolic processes during adaptation to unusual and difficult living conditions, it is interesting to investigate the dynamics of amino acid metabolism of cosmonauts during flights differing in duration. The data thus obtained could be used both for biochemical evaluation of metabolism and physiological assessment of the function of several organs (liver, kidneys), as well as to improve the diet and set standards for inflight exercise. Examination of cosmonauts following 140- and 185-day missions revealed a tendency toward reduction of the pool of free amino acids (FA) and concentration of many of them [7, 8], which requires several preventive measures.

A. S. Ushakov, T. F. Vlasova and some other researchers have demonstrated a decline of amino acid levels after a 185-day flight [11].

We shall submit here the results of assaying 17 FA in blood plasma of the commander (CDR) and flight engineer (FLE) of the Salyut-7--Soyuz-T orbital research complex before and after a 211-day mission.

Methods

We assayed 17 free amino acids in blood plasma of the cosmonauts during the period of preflight preparations in the course of a routine clinical and physiological examination (CPE), then on the 1st and 7th days after their 211-day flight. As in our previous studies [5, 7, 8], we measured concentrations of amino acids in samples of venous blood plasma drawn and treated by standard methods [2, 13, 16], using a Hitachi (model KLA-3B) automatic amino acid analyzer. The obtained values were compared to those of other authors for normal blood amino acid levels.

Results and Discussion

The Table lists data concerning levels of 17 FA in blood plasma of the CDR and FLE of the Salyut-7--Soyuz-T orbital research complex before and after a 211-day flight.

During the period of the preflight CPE, the concentrations of most amino acids in blood plasma were in the range of "approximate data for healthy adults" cited by I. S. Balakhovskiy [1] in both cosmonauts. The only exceptions were threonine, methionine and aspartic acid. Blood threonine content was 1.63 mg% higher than the top of the range of physiological fluctuations in the CDR. His methionine concentration was 0.03 mg% less than the bottom of this range. In the FLE, plasma methionine content was only 0.02 mg% higher than the bottom of the physiological range. Consequently, if we judge from this norm, methionine content was relatively low in plasma of both cosmonauts: on the level of the bottom of the range of physiological fluctuations for healthy adults. Plasma aspartic acid concentration was considerably lower in both cosmonauts than the bottom of the physiological range according to [1]: by 1.81 mg% for the CDR and by 1.83 mg% for the FLE.

Other authors [3, 10, 12, 15] also cite lower values as the top of the range of physiological fluctuations of plasma threonine than the concentration found in the CDR.

Average levels of blood plasma threonine, which we found in a screening of 124 healthy males under ordinary living conditions, were considerably lower than in the CDR, as well as FLE before the flight. On the basis of a screening of 80 people, A. S. Ushakov and T. F. Vlasova [11, 17] also cite lower mean values for plasma threonine than in the CDR and FLE.

It should be noted that, in the past, examination of the crew of Salyut-6 prior to a 140-day mission, revealed even higher blood plasma threonine concentration in the flight engineer, 4.14 mg%, and it also remained high after the flight--3.43 mg%, i.e., above the norm cited in [7]. Such elevated plasma threonine level could be due to individual distinctions of metabolism of this amino acid, of protein metabolism as a whole, as well as dietary differences (high intake of threonine in individual diet, some imbalance of amino acids in food).

FA levels in blood plasma of crew of Salyut-7--Soyuz-T orbital research complex before and after 211-day flight

Amino acid	CDR					FLE				
	preflight	postflight L+1	inflight change mg%	inflight change % of base value	postflight L+7	preflight	L+1	inflight change mg%	inflight change % of base value	L+7
Essential amino acids (EA)										
Lysine	2.96	2.58	- 0.38	- 12.83	1.82	3.60	2.82	- 0.78	- 21.66	1.79
Threonine	3.63	3.86	+ 0.23	+ 6.33	3.31	2.66	2.57	- 0.09	- 3.38	2.17
Valine	2.71	1.95	- 0.76	- 28.01	1.74	2.72	2.18	- 0.54	- 19.85	1.94
Methionine	0.27	0.15	- 0.12	- 44.44	0.25	0.32	0.22	- 0.10	- 31.25	0.19
Isoleucine	0.74	0.53	- 0.21	- 28.37	0.60	0.68	0.63	- 0.05	- 7.35	0.61
Leucine	1.55	1.12	- 0.43	- 27.74	1.00	1.30	1.06	- 0.24	- 18.46	1.03
Phenylalanine	0.96	0.77	- 0.19	- 19.79	0.60	0.97	0.54	- 0.43	- 44.32	0.61
Total EA	12.82	10.96	- 1.86	- 14.44	9.32	12.25	10.02	- 2.23	- 18.20	8.38
Nonessential amino acids (NA)										
Histidine	1.00	1.11	+ 0.11	+ 11.0	0.77	1.19	0.97	- 0.22	- 18.48	0.61
Arginine	1.33	1.16	- 0.17	- 12.78	0.83	2.01	1.50	- 0.51	- 25.37	0.69
Aspartic acid	0.19	0.09	- 0.10	- 52.63	0.16	0.17	0.14	- 0.03	- 17.64	0.07
Serine	1.60	1.60	0.00	0.00	2.06	1.66	1.04	- 0.62	- 37.34	1.34
Glutamic acid	3.79	3.12	- 0.67	- 17.67	3.40	3.06	3.05	- 0.01	- 0.32	3.14
Proline	2.24	1.68	- 0.56	- 25.0	2.33	2.23	2.05	- 0.18	- 8.07	1.53
Glycine	1.41	1.71	+ 0.30	+ 21.27	1.70	1.03	1.73	+ 0.70	+ 67.96	1.31
Alanine	2.60	3.48	+ 0.88	+ 33.84	2.98	2.47	3.05	+ 0.58	+ 23.48	2.47
Cystine	0.70	0.33	- 0.37	- 52.85	0.24	0.41	0.22	- 0.19	- 46.34	0.47
Tyrosine	1.02	1.07	+ 0.05	+ 4.90	0.68	0.88	0.49	- 0.39	- 44.31	0.72
Total NA	15.88	15.35	- 0.53	- 3.57	15.15	15.11	14.24	- 0.87	- 5.75	12.65
Total amino acids	28.70	26.31	- 2.39	- 8.32	24.82	27.36	24.26	- 3.10	- 11.33	21.03
EA/NA ratio	0.80	0.71	- 0.09	- 11.25	0.62	0.81	0.70	- 0.11	- 13.58	0.66

A comparison of concentrations of methionine in the CDR and FLE to data of other authors established that the levels of this amino acid were relatively low in the cosmonauts. In the CDR, plasma methionine content was lower than the bottom of the range according to [3, 10, 12, 15] and in the FLE at the bottom of the range of physiological fluctuations. Judging from mean values obtained by several authors [4, 9, 14, 17], as well as by us in testing 124 people, the methionine concentration was below the average norm in both cosmonauts.

Blood plasma aspartic acid content was quite similar in both cosmonauts and on a considerably lower level than the bottom of the physiological range according to [1]. At the same time, several other authors [10, 12, 15] suggest lower values as the bottom of the normal range than I. S. Balakhovskiy, which are closer to those found in the CDR and FLE. Interestingly enough, B. I. Zbarskiy et al. [3] do not cite standards for aspartic acid at all in their norms. The mean values for aspartic acid cited by a number of authors [4, 9, 14, 15, 17]

were also lower than those of I. S. Balakhovskiy, but differed somewhat from the concentrations demonstrated in CDR and FLE. Some authors cited lower values [4, 9, 14] and others, higher ones [15, 17]. Our testing of 124 healthy adult men revealed similar mean value for concentration of aspartic acid, 0.29±0.07 mg%. A comparative analysis revealed significant differences between the norms for blood plasma aspartic acid levels cited by different authors. Evidently, the level of this amino acid is quite variable and depends strongly on conditions of vital function, nutrition and individual differences in metabolism. Methodological differences probably play some part also.

General indicators of amino acid status (total amino acids, total essential and nonessential amino acids) of both cosmonauts were in the range of physiological fluctuations of these parameters according to [1, 10, 12, 15]. The means of these general indicators, obtained by us in a screening of 124 healthy men under ordinary living conditions, were similar to the values found preflight for the CDR and FLE.

To sum up the results of our study of preflight amino acid status of cosmonauts, it can be concluded that the supply of most amino acids was satisfactory in the preflight period. Only methionine, cystine and aspartic acid values were low.

Testing before the flight, when both cosmonauts were under similar living conditions and received a daily food allowance in the pilot's mess hall that was analogous in nutritional value, total of 17 free amino acids in blood plasma was 1.34 mg% greater for the CDR than FLE, constituting 4.7% with a 12% margin of error. In the CDR, the total of 7 essential aminoacids was 0.57 mg% (4.5%) greater and total of 10 nonessential amino acids was 0.77 mg% greater (4.9%).

Since NA and EA content was lower by about the same values in the FLE than the CDR, the NA/EA ratio was virtually the same in both cosmonauts (0.80 and 0.81 for the CDR and FLE, respectively), although the pool of FA in blood plasma of the CDR was larger in absolute value. As for levels of different amino acids, there was somewhat more threonine, isoleucine, leucine, glutamic acid, glycine, alanine and cystine (7 amino acids) in plasma of the CDR, but relatively less lysine, methionine, histidine, arginine and serine (5 amino acids), while the concentrations of valine, phenylalanine, aspartic acid and proline (4 amino acids) were very similar.

Testing on the 1st day after the 211-day mission revealed a decline in blood plasma concentrations of most amino acids in both cosmonauts, as compared to their preflight status. The CDR presented a decrease in concentrations of 11 out of 17 amino acids. At the same time, there was no change in plasma serine level, while threonine, histidine, glycine, alanine and tyrosine levels even rose. The changes in concentrations of 11 amino acids exceeded the margin of error of the method, which constituted 12%. It should be noted that the concentration of 6 out of 7 EA diminished. Only the plasma threonine content, which was above normal in the CDR in the preflight period [1] failed to decrease after the mission; rather, it increased even more (by 6.33%), beyond the top of the range of physiological fluctuations, apparently due more to individual distinctions of metabolism of this amino acid in the CDR than to changes in living conditions and nutrition. Among the EA, methionine, isoleucine, valine and leucine presented the maximum decline (by 44.4%, 28.4%,

28.4% and 27.7%, respectively). There was less decrease in concentrations of phenylalanine (by 19.8%) and lysine (by 12.8%). The inflight changes in free amino acids were in different directions. A decrease in concentration was found in 5 out of 10 FA, i.e., in half of them. There was the greatest decline in concentrations of cystine (by 52.9%), aspartic acid (by 52.6%), proline (by 25%) and glutamic acid (by 17.7%), and to a lesser extent of arginine (by 12.8%). We should call attention to the significant decline of level of plasma cystine, synthesis of which is closely related to metabolism of methionine, since the level of the latter also dropped significantly during the flight. The FLE showed a decrease in concentrations of 14 out of 17 amino acids. Plasma glutamic acid content underwent virtually no change, while glycine and alanine even increased. It should be noted that there was a decrease in concentrations of all essential amino acids. The greatest decline was referable to phenylalanine (by 44.3%), methionine (by 31.3%), lysine (by 21.7%), valine (by 19.9%), leucine (by 18.5%) and, to a lesser extent, isoleucine (by 7.4%) and threonine (by 3.4%). Of the NA, there was the greatest decline in concentrations of cystine (by 46.3%), tyrosine (by 44.3%), serine (by 37.3%), arginine (by 25.4%), histidine (by 18.8%), aspartic acid (by 17.6%) and, to a lesser extent, proline (by 8.1%). We must call attention to the significant decline of plasma levels of cystine and tyrosine, the metabolism and synthesis of which are closely related to supply and metabolism of methionine and phenylalanine, respectively. As indicated above, the concentrations of methionine and phenylalanine in plasma diminished appreciably in the FLE after the flight. Interestingly, in the CDR, the significant decrease in methionine concentration was associated with substantial decrease in cystine concentration. At the same time, the decrease in concentration of phenylalanine in the CDR (true, it was moderate and less significant than in the FLE) was associated with some increase, rather than decrease, in tyrosine concentration.

Total amino acids, as well as total EA and NA in plasma were lower in both cosmonauts on the 1st postflight day than in the preflight period. In both cosmonauts, the EA/NA ratio on L+1 was lower than in the preflight period. This ratio decreased in both cosmonauts due to relatively more intensive decline of total plasma essential amino acids.

In spite of the general tendency toward postflight decline of amino acid concentrations in plasma, on L+1 most of them were in the range of the "approximate data for adults" cited in the Great Medical Encyclopedia [1]. This applies, first of all, to lysine, threonine, valine, arginine, alanine, serine, glutamic acid, proline and glycine. Plasma methionine level was below normal according to [1] even prior to the flight in the CDR; after the flight this parameter dropped even more. In the FLE, preflight concentration of methionine in blood was at the bottom of the normal range and 0.8 mg% lower after the flight. The concentration of cystine, metabolism of which is related to methionine according to Muller [15], was below normal already before the flight in both cosmonauts, and dropped even more after it. Judging by the mean concentrations of cystine that we found in 124 healthy males, plasma cystine content obviously dropped in both cosmonauts and was below the normal range. The concentration of isoleucine decreased to the bottom of the normal range in the CDR, while the concentration of leucine dropped to the same levels in both cosmonauts. In both cosmonauts, phenylalanine content came close to the bottom of the normal range, particularly

in the FLE. His tyrosine level dropped below normal values, whereas it had been in the range of physiological fluctuations before the flight. Histidine concentration in plasma dropped to the bottom of the normal range in the FLE [1]. The concentration of aspartic acid dropped below the norm according to [1]. However, according to the data of other authors [3, 10, 12, 15], aspartic acid content in plasma of both cosmonauts was close to average physiological fluctuations. At the same time, judging by the mean levels of this amino acid, which we found in 124 healthy males, as did A. S. Ushakov and T. F. Vlasova [11, 17] using an identical automatic analyzer, postflight concentration of aspartic acid was substantially lower than values demonstrable under ordinary living conditions, which are considered to be the norm.

Assays of total amino acids in blood plasma on L+1 revealed that it was somewhat greater in the CDR, by 2.05 mg%, than in the FLE (or 7.8%, with a ±2% margin of error in the method). The sum of 7 EA was also greater in the CDR, by 0.94 mg% (or by 8.6%) and the sum of 10 NA by 1.11 mg% (or by 7.2%). Consequently, in spite of the seemingly more homogeneous living conditions and nutrition in flight than before it, the difference in overall parameters of the amino acid pool became greater after the flight than in the preflight period. The causes of this phenomenon could be both individual metabolic differences and dissimilar actual diet, as well as a nonidentical schedule of activities during the flight itself (for example, different performance of exercises).

Postflight the EA/NA ratio declined in both cosmonauts, but to about the same extent. As for the different amino acids, in the plasma of the CDR, there was somewhat more threonine, leucine, phenylalanine, histidine, serine, glutamic acid, alanine, cystine, tyrosine (9 amino acids), but relatively less lysine, valine, methionine, isoleucine, arginine, aspartic acid and proline (7 amino acids) after the flight, while glycine concentration was very similar in both cosmonauts. Consequently, the difference in preflight and postflight levels of 9 amino acids was altered. Thus, preflight isoleucine and glycine concentrations were higher in the CDR and postflight in the FLE. Preflight histidine and serine levels were higher in the FLE, and they were higher postflight in the CDR. The impression is formed that there was no leveling off of plasma amino acid levels in the two cosmonauts.

Testing of the cosmonauts on L+7 revealed that total amino acids, total essential and nonessential amino acids were even lower than on L+1. Consequently, the above-mentioned general parameters did not present a noticeable tendency toward recovery to the preflight base level. This could be attributable to intensive utilization of amino acids for recovery processes of an anabolic nature, primarily in the muscular system, during readaptation to earth. On the other hand, this is indicative of the fact that there was relatively inadequate intake of amino acids with the postflight food allowance. Blood plasma of the CDR contained lower amounts of 10 out of the 17 amino acids--lysine, threonine, valine, leucine, phenylalanine, histidine, arginine, alanine, cystine, tyrosine--on the 7th postflight day than on L+1, i.e., most of the amino acids were involved. In the FLE, blood plasma contained less lysine, threonine, valine, methionine, histidine, arginine, aspartic acid, proline, glycine and alanine, i.e., also 10 out of 17 amino acids, than on the first postflight day. The changes in levels of a significant number of amino acids were in the same direction. We should mention that both cosmonauts presented increase in concentration

of glutamic acid, which is apparently a reflection of intensification of transamination processing during prevalence of anabolic over catabolic phenomena in the body.

As compared to the results obtained when cosmonauts were tested before and after a 185-day flight [8], there was less marked decline of overall pool of amino acids after the 211-day mission. However, on L+7, these parameters had a tendency toward recovery to base levels after the 185-day flight, whereas after the 211-day one they even worsened.

The results of our study of levels of 17 free amino acids in blood plasma of the CDR and FLE before and after their 211-day flight enables us to conclude that a supplement to the preflight diet of methionine, cystine, aspartic acid and of all seven essential amino acids to the inflight and postflight food allowance should improve the supply of these amino acids during long-term flights. The pool of nonessential amino acids of blood plasma was increased during long-term flight and in the recovery period by enriching the diet primarily with cystine, aspartic acid, arginine and proline.

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CIRCADIAN RHYTHM OF HUMAN BODY TEMPERATURE DURING SPACEFLIGHTS

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 6, Nov-Dec 84 (manuscript received 11 Jul 83) pp 15-18

[Article by L. Lhagwa (Mongolian People's Republic)]

[English abstract from source] The axillary temperature of the Mongolian Salyut-6 crewmember was measured in the daytime before, during and after flight. The temperature was recorded immediately after awakening to going to sleep every 2 hours: a month prelaunch in the Cosmonauts' Training Center during 5 days, a week prelaunch at the Baikonur launch site during 3 days, inflight from the middle of mission day 2 to the middle of mission day 7 every day, and postflight at Baikonur during 4 days. It was found that inflight the axillary temperature decreased significantly by 0.44°C as compared to the data obtained in the Cosmonauts' Training Center and by 0.22°C as compared to the data obtained at the launch site. There were also some changes in the pattern of acrophases on the time scale. It is recommended to continue thermal regulation measurements in space flight.

[Text] In view of the development of general and space biorhythmology, investigation of biological rhythms during spaceflights is attracting the increasing attention of researchers.

As we know, the body is subject to various stressors in space, including weightlessness. The role of weightlessness as a potential desynchronizer of circadian biological rhythms has been discussed repeatedly in the special literature [1-3, 5, 6] and was confirmed by the results of studies conducted during the mission of the American satellite, Biosatellite-3 [7]. The adverse effect of weightlessness on the human body is manifested the most acutely for the first 3-5 days of flight. It can be assumed that this period is associated with changes in circadian rhythm of vital functions.

Our objective here was to investigate the circadian rhythm of human body temperature from the middle of the 2d to middle of the 7th day in space.

Methods

This investigation was conducted in February-April 1981, before, during and after the spaceflight, in which there was a participating cosmonaut-scientist

from MNR [Mongolian People's Republic] aboard the Salyut-6 orbital station. At all of the indicated stages, we took axillary temperature of the MNR cosmonaut (using a medical mercury thermometer before and after the flight, and an ET-10 electric thermometer during the flight; in all cases, the scales had 0.1°C graduations). The preflight examination was performed at the Cosmonaut Training Center (CTC) on 5 successive days and at the Baykonur spaceport for 3 successive days; postflight examination was performed at the Baykonur spaceport for 4 days. Before and after the flight, temperature was taken at 2-h intervals from 7 am to 11 pm Moscow time. Thus, we assessed the dynamics of body temperature during the daytime part of the 24-h cycle, i.e., only during the waking period. It must be noted that the participants of the Soviet-Mongolian mission were on Moscow time at the spaceport, which was 2 h behind local time. On the 2d day of the postflight examination (1 April 1981), there was a change from standard to daylight saving time, as a result of which there was a 1-h counterclockwise shift in rising and going to bed times.

Temperature was measured during the flight at 2-h intervals throughout the waking period, from the time the cosmonaut got up to his bed time, for 5 days: from 12 noon to 12 midnight on the 1st day, from 10 am to 10 pm on the 2d day, 8 am to 10 pm on the 3d and 4th days, 10 am to 10 pm on the 5th day, all on Moscow time.

The readings were entered in the log and relayed to earth via telemetry.

Results and Discussion

Table 1.
Body temperature at different stages of study (arithmetic means at each point in time)

Preflight			Postflight	Inflight	
Moscow time hours	temp., °C		temp. °C	Moscow time hours	temp. °C
	I	II			
7	36.00	35.97	35.75	8	35.35
9	36.16	35.87	36.05	10	35.65
11	36.12	36.13	36.20	12	35.94
13	36.22	36.07	35.98	14	36.10
15	36.32	36.03	36.36	16	35.90
17	36.24	36.00	36.50	18	35.86
19	36.26	35.87	35.98	20	35.88
21	36.50	36.43	36.20	22	35.80
23	36.32	35.80**	36.33***	24	35.70*

I) CTC II) Baykonur
*One reading
**Average of two readings
***Average of three readings

Note: Temperature was taken at the same times before and after the flight.

Table 1 lists data on daytime dynamics of axillary temperature at different stages of the study (values averaged for each stage). We were impressed by the fact that the readings taken during the preflight examination at the spaceport were lower in the absolute majority of cases than at the CTC. If we compare the two series of values, which correspond to columns I and II (see Table 1), we shall find that the difference between them is statistically significant ($P<0.01$ according to Wilcoxson).

As can be seen in Table 2, preflight daily maximum temperatures differed appreciably at the CTC and Baykonur, whereas minimums were noticeably lower in the latter case than in the former. Analysis of distinctions of actual (i.e. not averaged) temperature curves characterizing the daily dynamics of this functional parameter revealed high variability of axillary temperature in the course of the day

with steep rises and declines at the spaceport and considerably "calmer," smooth curves at the CTC. This is confirmed by the data in Table 3.

Table 2. Daily maximum and minimum axillary temperature and difference (°C)

Time of reading	Maximum		Minimum		
	range of actual variation	$\bar{x}_1$	range of actual variation	$\bar{x}_2$	$\bar{x}_1 - \bar{x}_2$
CTC	36.4-36.7	36.5	35.9-36.1	36.0	0.5
Baykonur preflight	36.5-36.6	36.5	35.4-35.7	35.5	1.0
Spaceflight	35.9-36.7	36.2	35.3-35.7	35.5	0.7
Baykonur postflight	36.4-36.7	36.6	35.5-35.8	35.7	0.9

Note: $\bar{x}$ is arithmetic mean

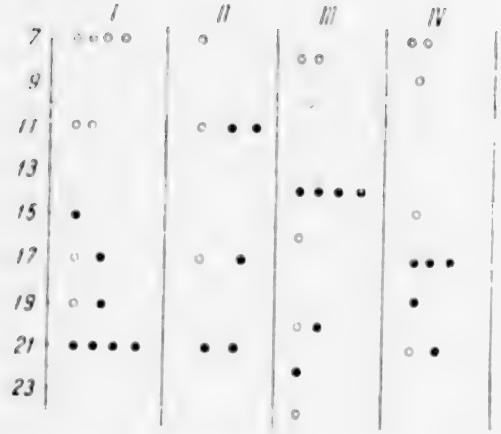
Table 3. Axillary temperature (°C) in the morning, daytime and evening at the CTC (I) and Baykonur spaceport (II) (arithmetic means and standard deviations)

Time of day	I	II
Morning (7-11 am)	36.1±0.12	36.0±0.39
Daytime (1-5 pm)	36.3±0.14	36.0±0.35
Evening (7-11 pm)	36.4±0.21	36.1±0.35

Thus, axillary temperature preflight at Baykonur spaceport was lower than at the CTC, and it was also quite unstable during the day. This could be due to the fact that the situation was unquestionably more stressful during the examination at the spaceport 1 week before launch than at the CTC 1 month before lift-off with respect to both fullness of work program and psychological state. Evidently, intensive and irregular perspiration in the course of the day in the axillary region (and other parts of the body) resulted from this stress and led to noticeable axillary temperature fluctuations against a background of some general decline of this parameter.

It can be assumed that preflight stress caused a change in correlation between morning and evening temperatures: morning readings at the CTC at 7 am were lower than at 11 pm, whereas in the spaceport they were higher at the latter time (see Table 1).

According to the data in Table 1, there was a decline of axillary temperature during the spaceflight, as compared to both preflight stages. Quantitatively, this difference can be evaluated by subtracting arithmetic mean temperatures in the relevant vertical columns of Table 1 and obtaining a mean value for each stage of the examination characterizing body temperature at that stage. Estimates revealed that this temperature is 36.24°C at the CTC, 36.02°C for the preflight reading at the spaceport and 35.80°C during flight. Consequently, there was an inflight temperature drop of 0.44°C, as compared to the value at the CTC and a 0.22°C drop in body temperature, as compared to readings at the spaceport.



Position of maximums (black circles) and minimums (white circles) on Moscow time scale at different stages of study. Y-axis, Moscow time (hours)
I) CTC
II) Baykonur preflight
III) in flight
IV) Baykonur postflight

A comparison of inflight values listed in Table 1 to preflight ones listed in columns I and column II of the same table with use of White's statistical criterion T revealed that the differences were substantial ($P<0.01$ for column I and $P = 0.05$ for column II).

There was a decline of numerical values of 24-h maximums of axillary temperature during the flight; as for the minimums, a decline can be discussed only in comparison to values recorded at the CTC (see Table 2).

The Figure illustrates data on the location of daily maximums and minimums of axillary temperature on the Moscow time scale. It shows that the preflight maximums at the CTC were referable to the second half of the day, with concentration at the 9 pm point, while minimums coincided mostly with morning hours (7-11 am). The small number of data obtained preflight at the spaceport compels us to abstain from any comments. Inflight maximum temperature was most often recorded at 2 pm and less often at 8-10 pm, the minimums occurring both in the morning, daytime and evening hours, up to midnight. Thus, there are grounds to refer to some changes in placement of maximums and minimums on the inflight time scale, as compared to the findings 1 month before the flight. In essence they consist of shift of maximums to earlier hours (perhaps it would be more correct to refer here only to a tendency toward such a shift, since there was no total shift of maximums to 2 pm).

Postflight body temperature was close to preflight values (see Table 1). Maximums were in the range of 5 to 9 pm, i.e., they "departed" from 2 pm to a later time (see Figure), while the numerical values rose to preflight levels (see Table 2).

The drop of body temperature in space throughout the waking period should be considered the most relevant result of our study (judging by the literature available to us, this was demonstrated for the first time in man). There is reason to believe that this phenomenon is related in part to the decrease in tone of skeletal muscles in weightlessness and related decrease in thermogenesis [7]. Nor can we rule out the effect of psychogenic perspiration in the unique flight situation, as well as, perhaps, excessive perspiration against the background of vestibulovegetative instability, which is inherent in the first stage of spaceflight (although it should be noted that no overt signs of such instability were observed in the MNR cosmonaut). It is necessary to conduct further investigation of the process of heat regulation during spaceflights, with recording of temperature not only from superficial, but deep regions of the body during the day and night.

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BIOCHEMICAL STATUS OF ADRENOCORTICAL DYSFUNCTION FOLLOWING SPACEFLIGHT

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 6, Nov-Dec 84 (manuscript received 1 Mar 83) pp 18-22

[Article by R. A. Tigranyan, L. I. Voronin and N. F. Kalita]

[English abstract from source] Renal excretion of 17-HOCS and aldosterone as well as the ratio of excreted glucocorticoids and their precursors was investigated in the Soyuz-31 Commander before and after his 7-day flight. Renal excretion of total 17-HOCS remained unchanged while hydroxylation in positions 11 and 17 in the course of corticosteroid synthesis was relatively deficient.

[Text] Data have been previously obtained indicative of the possibility of development of adrenocortical dysfunction at the early stage of readaptation to earth's gravity [6, 7].

We submit here the results of testing the functional state of the adrenal cortex of the commander of Soyuz-31 spacecraft after completing a mission. The obtained data were compared to the findings of a study of adrenocortical function in the same commander after completing a spaceflight aboard Soyuz-22.

Methods

The material used to assay corticosteroids (CS) was 24-h urine, which was collected 28 days before the flight, during the 5 days preceding the launch of Soyuz-31 spacecraft, as well as on the day of landing (L+0) and for the first 5 postflight days. On L+0, urine was collected after the last micturition in space up to 8 am of the following day.

Methods described in [5, 10] were used to assay total 17-hydroxycorticosteroids (17-HC), their free forms and conjugates with strong acids, and aldosterone by the RIA [expansion unknown] method. Thin-layer chromatography on silica gel [1, 9] was used to determine relative parameters of glucocorticoid function of the adrenals; we also identified and made a quantitative assay of cortisol (F), cortisone (E), corticosterone (B), 11-deoxycortisol (S), tetrahydrocortisol (THF), tetrahydrocortisone (THE), tetrahydrocorticosterone (THB) and tetrahydro-deoxycortisol (THS). Quantitative assay of different corticosteroids

after their reaction with blue tetrazolium was made by the densitometric method at a wavelength of 575 nm using the Chromoscan-200/Scan-201 instrument (England). Relative indicators of adrenal glucocorticoid function were calculated from the values for different CS on chromatograms.

We assessed 17-hydroxylase activity of the adrenals from the 17-hydroxicorticosteroids/17-dehydroxycorticosteroids ratio (17-HC/17-DHC = THF + THE + THS + F + E + S/THB + B) [6]. In addition, we calculated the coefficient THS + S/THF + F + THE + E, which enables us to assess intensity of glucocorticoid synthesis [4]; from the biochemical point of view, this coefficient reflects adrenocortical 11-hydroxylase activity [8].

Individual preflight values were taken as the base for assessing the degree of postflight alteration of adrenocortical function. At the same time, the obtained data were compared to normal parameters established in the laboratory for the given group of individuals and to parameters obtained for the same cosmonaut after completion of a spaceflight aboard Soyuz-22. This cosmonaut had not taken any drugs during the flight or in the postflight period.

Results and Discussion

Preflight and prelaunch levels of the parameters studied were essentially in the normal range in the cosmonaut of Soyuz-31, and in some cases only excretion of total 17-HC exceeded normal values. After the flight, excretion of total 17-HC in urine was on the level of preflight values, whereas excretion of free forms was above normal on L+1 and so was that of sulfates on L+4-5. Aldosterone excretion in urine increased on L+0, 1 and 3, and exceeded normal values. However, it should be borne in mind that for L+0 there was incomplete collection of 24-h urine, so that the levels of excretion of total 17-HC and aldosterone were low that day (see Table).

As compared to the preflight range of fluctuations, there was decline of 17-HC/17-DHC ratio on L+0-L+3, while the THS + S/THF + F + THE + E ratio rose. (see Table). At the same time, on the 1st and 2d days of the postflight period, when the observed changes were the most marked, there was no distinct separation on chromatograms of CS following THE, on the basis of which we assumed, as we did in prior studies [6], that on the level of this spot there is an unidentified substance that prevents normal separation of other steroids because of its relatively high concentration. Figures 1 and 2 illustrate samples of chromatograms and densitograms obtained for the cosmonaut during a normal work and rest schedule before the flight, as well as in the period of readaptation to earth's gravity after it. Figures 1a and 2a illustrate normal preflight chromatograms and densitograms, while Figure 1b and 1c shows chromatograms obtained on L+1 and L+2. As compared to preflight data, there is an unstained white spot on these chromatograms, between THS and F, while the THS and F fractions formed a corona around it. This unstained spot is lighter than the rest of the chromatogram background, on which there is uniform distribution of nonspecific admixtures of urine.

It should be noted that findings very similar to these had been made on the same cosmonaut in the recovery period after completing a spaceflight aboard Soyuz-22 (see Figure 1d) [6].

Dynamics of parameters of adrenocortical function in commander of Soyuz-31 spacecraft before the flight and in the postflight period

Parameter	Preflight, day								Postflight, day					Normal range
	-	5	1	3	2	1	0	1		3	1	5	
17-HC:														
total, mg/day	9.58	7.14	8.31	9.28	11.18	6.24	7.16	11.53	8.83	7.02	3.90	10.0		[illegible]
free, %	14	7	18	6	2	14	14	17	14	14	12	12		[illegible]
glucuronides, %	71	70	69	79	65	62	71	65	69	68	54	61		[illegible]
sulfates, %	15	23	13	15	33	24	15	18	17	18	34	27		14–23
aldosterone, µg/day	15.0	15.0	15.1	14.8	14.8	17.2	23.3	25.3	17.6	20.6	17.2	16.7		[illegible]
THS+S/THF+F+THE+E	0.165	0.161	0.183	0.157	0.201	0.160	0.209	0.466	0.306	0.217	0.163	0.163		
17-HC/17-DHC	3.38	5.94	5.37	6.40	4.90	6.30	3.92	3.09	2.67	4.15	5.75	5.54		

Conditions for complete chromatographic separation of THS fraction from the white spot were provided by reducing the amount of urine extract on the 1st and 2d postflight days (see Figures 1e, 2c and 2d). In addition, the amount of preflight urine was such (see Figure 2b) as t to have about the same quantity of THE fraction on the chromatogram after separation as on the densitogram (see Figure 2c). Figure 2b shows that there are trace amounts of fraction THS, while virtually no THB is demonstrable in normal prefligt urine, as compared to THF and THE fractions. In contrast, the relative amount of THS exceeded THE in urine collected on L+1 (see Figure 2c); relative amount of THB was also increased, as compared to preflight level. Moreover, there was distinct lag of isoline between THE and THS fractions (closer to THS), due to the light background formed because of displacement of nonspecific urine admixtures by the unidentified substance.

In all likelihood, this substance is referable to earlier precursors of glucocorticoids (17-hydroxyprogesterone type and others), which do not react with blue tetrazolium because of absence of α-k>tol group in the side chain; in addition, its steroid structure is unquestionable, since this substance does not change to petroleum ether when urine is treated and its mobility is close to that of the tested CS.

The increased excretion of total 17-HC in urine the day before the launch should apparently be viewed as the result of nervous and emotional stress, which is inherent in the final phase of preparations for the launch. The similarity of postflight levels of daily excretion of total 17-HC and preflight values is, at first glance, indicative of

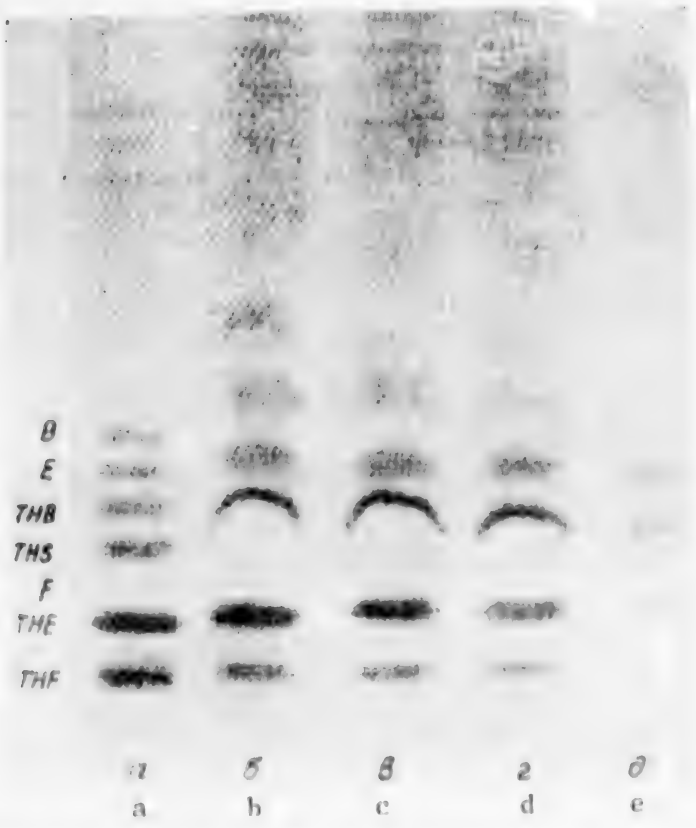

Figure 1. Chromatograms of urine CS of commander of Soyuz-31 spacecraft. Explanation given in the text

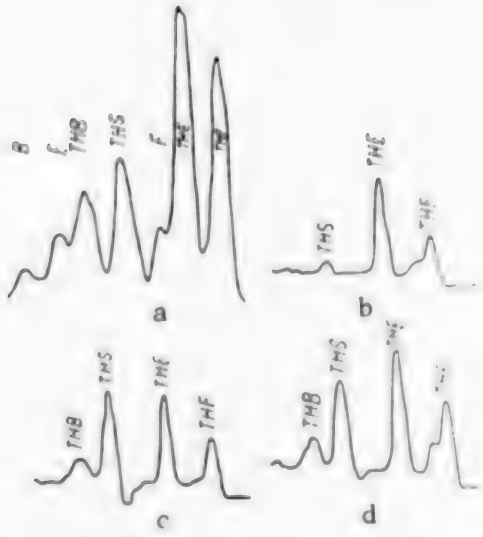

Figure 2.
Densitograms of urine CS of commander of Soyuz-31 spacecraft. Explanation given in the text

absence of distinct changes in adrenal glucocorticoid function. However, this is contradicted by the increase observed in the postflight period of THS + S/THF + F + THE + E coefficient and decline of 17-HC/17-DHC ratio, which could be interpreted as signs of adrenocortical dysfunction indicative of relative hydroxylation deficiency in positions 11 and 17 during synthesis of glucocorticoids. Similar changes in CS ratio had been found in other extreme states [2, 3] and had been interpreted by the cited authors as signs of adrenocortical dysfunction. Evidently, in our studies such changes could be due to excessive strain of adrenal glucocorticoid function during readaptation to earth's gravity. However, we cannot

rule out the possibility that weightlessness itself or the entire set of spaceflight factors somehow lowered the potential reserves of the adrenal cortex in the cosmonaut we tested for the purpose of supplying the body with the required amounts of proper glucocorticoids in the readaptation period.

Decline of the 17-HC/17-DHC ratio as an indicator of relative increase in synthesis of steroids with mineralocorticoid properties and increase in aldosterone excretion against this background could also be attributed to relatively deficient hydroxylation in position 17. This is apparently the cause of areactivity of the adrenal cortex in response to change from weightlessness to earth's gravity. In the preceding flight, with chnage in ratio between excreted steroids there was increased elimination in urine of total 17-HC [6], which is the main difference of the postflight adrenocortical reaction in the Soyuz-31 spacecraft commander. The percentile increase in sulfates in urine in the recovery period indicates that steroid metabolism also undergoes changes at the catabolic stage.

Thus, the data reported here indicate that adrenocortical dysfunction, as manifested by relative hydroxylation deficiency in positions 11 and 17 during CS synthesis, may be the cause of intact excretion of total 17-HC in response to gravity stress after completion of the spaceflight. On the other hand, the results of our study revealed that the reaction of the adrenal cortex to change from weightlessness to earth's gravity is individually predetermined to some extent.

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COMPARATIVE ANALYSIS OF EFFECTS OF WEIGHTLESSNESS AND ITS MODELS ON VELOCITY AND STRENGTH PROPERTIES AND TONE OF HUMAN SKELETAL MUSCLES

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 6, Nov-Dec 84 (manuscript received 10 Jun 83) pp 22-26

[Article by I. B. Kozlovskaya, L. S. Grigor'yeva and G. I. Gevlich]

[English abstract from source] The effect of various types of support elimination (actual zero-g, water immersion and head-down tilt) on the strength-velocity properties and tone of leg muscles was investigated. With all the exposures used, there was a high correlation between the tone decrease and the strength potential of antigravitational muscles, as well as the degree of support elimination (immersion and bed rest). This suggests that the tonic changes associated with the decrease of the support in input are the major factor responsible for motor disorders during short-term exposures to zero-g.

[Text] Considerable data have been accumulated to date concerning the effect of real and simulated weightlessness on the human locomotor system, which indicate, in particular, that there is decline of strength of skeletal muscles [3, 6, 8 and others]. In the case of relatively prolonged exposure to weightlessness, the nature of these disturbances is attributed to deconditioning of muscles under hypokinetic conditions and development of muscular atrophy [2, 7]. The decrease in strength of skeletal muscles, which has been observed with short-term exposure to zero-G factors [1, 5, 9], could be due to other, more reactive mechanisms related to reflex decrease of muscle tone in response to absence of load-bearing.

In order to confirm this assumption, it was deemed expedient to conduct a comparative study of the effects of real and simulated weightlessness, which eliminates load-bearing, on strength-velocity and tone of skeletal muscles.

Methods

An isokinetic dynamometer, which permits recording moments of force generated when performing movements at a specified velocity, was used to examine the strength and velocity properties of the anterior tibial (ATM) and triceps of the calf (TMC). With the subject in standard position, his foot was attached to the pedal of the dynamometer in such a way as to have the axis of the ankle

joint coincide with the axis of pedal rotation. The set angular velocity of pedal movement constituted 180, 120, 60 and 0°/s. During the tests, when so instructed the subjects performed single and cyclic dorsal and plantar flexions of the foot with maximum possible strength and amplitude, making 5-6 movements at each velocity specified by an instrument. In analyzing the data, we averaged the parameters of three similar movements performed with maximum moment of force (at each velocity). Concurrently, we recorded the superficial EMG of the working sural muscles on a Mingograph-34 pen recorder. We assessed the amplitude characteristics of the EMG for all tested velocities.

To test muscle tone, we used a modified electromyotonometer, which permits recording independently the force applied to a sensor and tissue reaction, which is necessary to calculate lateral rigidity. The range of force of depression of the sensor was 1000-1500 g, which corresponded to optimum value for testing elastic properties of muscle tissue. Lateral rigidity of ATM and heads of TMC at rest and maximum isometric contraction was assessed with strict standardization of position and levels of relaxation and contraction. To standardize the latter, we used a training procedure with feedback for EMG (resting) level and developed moment of force (contraction).

The results were submitted to statistical processing using the Student method of pair comparisons.

This investigation was conducted on 18 essentially healthy men (immersion and antiorthostatic [head tilted down] bedrest hypokinesia lasting 7 and 14 days, respectively) and 11 crew members of visiting missions to the Salyut station (7-day spaceflights) ranging in age from 25 to 36 years.

Results and Discussion

All subjects presented significant decrease in force parameters of TMC over the entire range of tested velocities, including all velocity and isometric modes (Figure 1a) after both 7-day immersion hypokinesia and 7-day spaceflights. These changes were statistically reliable ($P<0.01$) with both factors. As can be seen in Figure 1, the decline of strength potential of TMC after immersion, as compared to background data, was rather uniform over the entire velocity range (about 30%), whereas after exposure to weightlessness this distinction was demonstrable only in the velocity *180 and 120°/s) and dynamic strength (60°/s) modes, whereas in isometric mode (0°/s) there was considerably less decline of force parameters for TMC (about 15%) than after immersion.

There was substantially less effect of immersion and weightlessness on force potential of ATM, and it was not reliably manifested in any of the tested modes, with the exception of isometric mode after immersion, when the decline of maximum ATM force moments constituted an average of about 20% ($P<0.01$).

Analysis of correlation between EMG amplitude and developed force moments (Figure 1b) was also indicative of decreased contractility of sural extensors after immersion and weightlessness: at all velocity and isometric modes of contraction there was a statistically reliable 1.5-2-fold increase ($P<0.01$) in this relationship. No appreciable differences were demonstrable in the change in this parameter after immersion and weightlessness in any of the

tested modes, with the exception of high velocity (180°/s), at which post-weightlessness changes were more marked. The analyzed relationship rose reliably ($P<0.05$) in the ATM only after immersion and only in isometric mode, thus repeating the changes observed in strength parameters of this muscle after immersion and weightlessness.

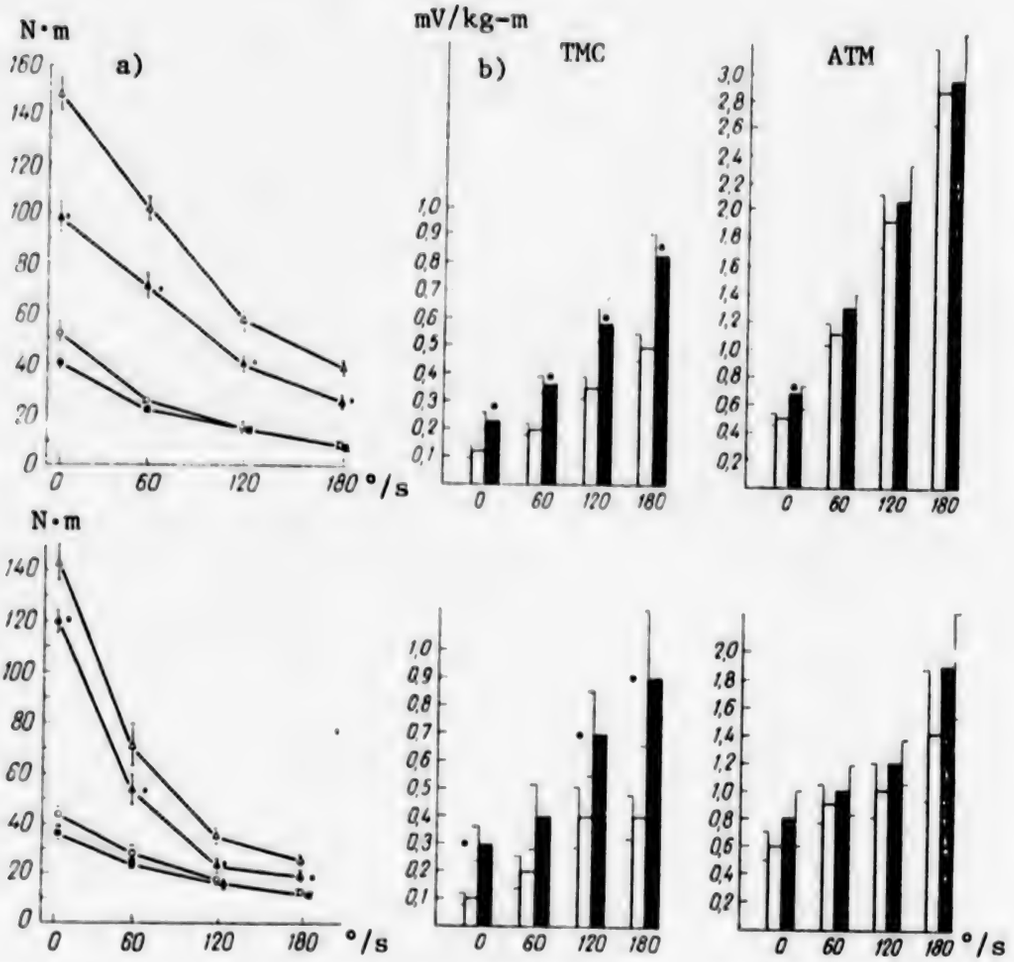

Figure 1. Velocity and strength parameters (a) and correlation between amplitude of bioelectric activity and developed force moments (b) for sural muscles before and after 7-day immersion hypokinesia and weightlessness

a) x-axis--angular velocity (°/s), y-axis, force moments (N·m); △ and ▲ -- TMC data before and 1-2 days after exposure to the factors; ○ and ● -- ATM data before and 1-2 days after exposure to the factors

b) x-axis--angular velocity (°/s), y-axis--correlation between EMG amplitude and developed force moments (in mV/kg-m); top--immersion, bottom--weightlessness; white bars before and black on 1st-2d day after exposure. Vertical segments refer to mean error; asterisks show statistically reliable differences ($P<0.01$)

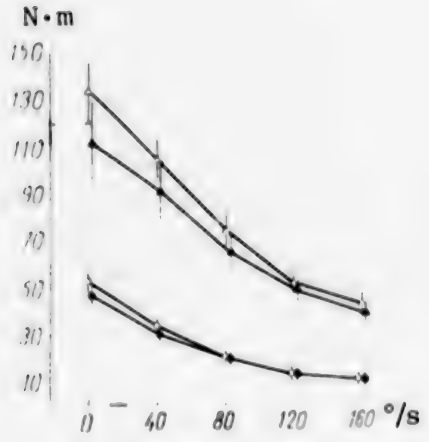

Figure 2.
Velocity and strength parameters of sural muscles before and after 14-day bedrest hypokinesia with head tilted down
X-axis, angular speed (°/s); y-axis, force moments (N·m); △ and ▲ are TMC data for background and 2d-3d day after exposure, respectively; ○ and ● are the same data for ATM. Vertical segments refer to standard errors

The nature of changes in velocity-force properties of sural muscles after 14-day bedrest hypokinesia in antiorthostatic position was analogous to those after immersion and weightlessness, and it was manifested by decline of strength parameters for TMC. However, there was considerably less decline (Figure 2), which did not exceed 15-20% in strength and isometric modes and was not manifested appreciably at high speed modes. No statistically reliable changes were demonstrable in this group. No substantial changes in group strength characteristics for ATM were demonstrable after hypokinesia in any of the tested modes.

The effect of various load-bearing conditions on muscle tone was manifested by a consistent decline of parameters of lateral rigidity of all three heads of the TMC: lateral and medial gastrocnemius, soleus (SM) (Figure 3). And, as was the case with change in force properties, there were substantial differences in dynamics and severity of changes in lateral rigidity of extensors with different types of factors: by the 2d day of exposure there was maximum decline of rigidity during immersion (40-50%), whereas in the case of alternating immersion and hypokinesia it did not exceed an average of 30% at this time and 15-20% for antiorthostatic hypokinesia (bedrest).

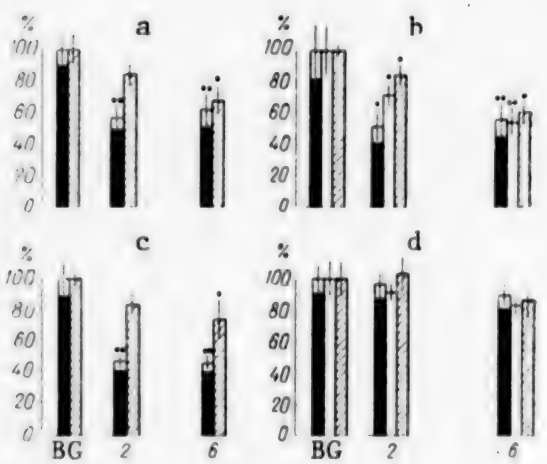

Figure 3.
Effect of different load-bearing conditions on lateral rigidity of resting sural muscles
X-axis, duration of exposure (days), y-axis, lateral rigidity (% of background); black bars--continuous immersion, white--alternating (every 12 h) immersion and head-down bedrest; striped bars--antiorthostatic hypokinesia
a-d) data for medial, lateral gastrocnemius, soleus and anterior tibial muscles, respectively
BG) background
Vertical segments indicate standard errors; one and two asterisks indicate reliable differences with $P<0.05$ and 0.01, respectively

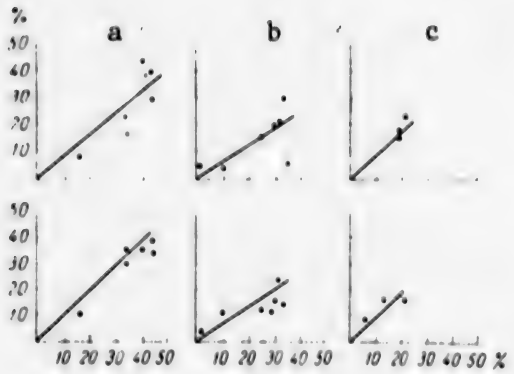

Figure 4.
Correlation between changes in maximum force moments of isometric contraction of TMC and its lateral rigidity at rest (top) and at maximum contraction (bottom) in weightlessness and under model conditions
X-axis, change in force (%); y-axis, change in lateral rigidity (%)
a-c) immersion, hypokinesia and weightlessness, respectively

As can be seen in Figure 3, lateral rigidity of ATM did not undergo consistent changes during exposure, regardless of its type.

Analogous distribution of extent of decline of lateral rigidity of TMC was also observed on the 1st-3d days after the indicated exposure (including postflight examination results), and there was decrease in severity of changes: the decline constituted 25-30% after 7-day immersion, 15-20% after 7-day spaceflights and 10-15% after antiorthostatic hypokinesia.

With all types of exposure, the changes in lateral rigidity of active TMC were analogous to those found at rest.

Correlation analysis revealed a close relationship between depth of changes in force properties, in particular, isometric strength and lateral rigidity of TMC at rest and with contraction (Figure 4), with a high coefficient of correlation (0.81-0.86). The results of statistical analysis confirmed the reliability of this relationship ($P<0.05$) for all types of exposure.

The high correlation between extent of decrease in tonus and force parameters of antigravity muscles demonstrated after 7-day weightlessness and conditions that simulated it, as well as consistency between extent of decline of force characteristics and tone of extensors in relation to absence of load-bearing (immersion and bedrest) enable us to view the tonic changes related to attenuation of load-bearing influx as the main factor in development of motor disturbances during brief exposure to weightlessness. Hypotheses concerning the link between motor disturbances with change in gravity loads and changes in muscle tone had been expounded previously by several authors [4, 5], who discovered signs of muscular atonia in their clinical examination of spacecraft crews.

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COSMONAUTS' BLOOD PLASMA FREE AMINO ACID LEVELS DURING PREFLIGHT TRAINING

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 6, Nov-Dec 84 (manuscript received 30 May 83) pp 26-28

[Article by T. F. Vlasova, Ye. B. Miroshnikova, I. N. Belozerova and A. S. Ushakov]

[English abstract from source] Taking into consideration metabolic specificities of cosmonauts, the data on their amino acid composition during preflight training were summarized. Seasonal variations produced no effect on the content of free amino acids of plasma. The analysis yielded a physiological norm for this population which can be used to identify more reliably changes in the amino acid composition of plasma after space flight.

[Text] Parameters of amino acid metabolism are of some diagnostic value in assessing the amino acid status in clinical practice and tests involving humans. Determination of free amino acids of plasma is important, since they occupy a key place in the body's biochemical processes. The data accumulated to date concerning plasma amino acid composition are essentially the result of processing clinical material, which leads to wide scatter of cited parameters taken as the physiological norm [1, 3, 4, 6]. And, as a rule, specific parameters were not taken into consideration, such as an individual's physical condition, age, diet, occupation and others, which makes it difficult to assess objectively the status of subjects, particularly in specific groups. Thus, the specifics of occupational activity of cosmonauts, which takes place under conditions of intensive training during preparations for a mission, cause distinctive redistribution of the amino acid pool of blood, which determines the levels of different free amino acids in peripheral blood. We have summarized here the results we obtained over a period of many years concerning plasma free amino acid content in cosmonauts during the period of preparing for spaceflights.

Methods

Concentrations of free amino acids in cosmonauts' blood plasma were assayed by ion-exchange chromatography using the KIA-3B (Japan) and Liquimat III (FRG) automatic analyzers [2, 7]. First, the plasma specimens to be tested were deproteinized with crystalline sulfosalicylic acid [5]. Venous blood was

drawn from the cosmonauts 1 month before spaceflights (during the period of their training for a flight).

Table 1. Free amino acids (mg%) in cosmonauts' blood plasma during preflight training period

Amino acid	Winter (n = 14)	Spring (n = 41)	Summer (n = 20)	Fall (n = 65)	Physiological norm (n = 141)
Isoleucine	0,67±0,05	0,79±0,06	0,75±0,04	0,70±0,04	0,73±0,05
Leucine	1,30±0,10	1,56±0,09	1,53±0,10	1,29±0,08	1,42±0,09
Valine	1,80±0,10	2,09±0,09	2,23±0,09	2,44±0,07	2,14±0,09
Threonine	3,26±0,11	2,08±0,12	1,93±0,15	2,32±0,11	2,40±0,12
Serine	1,23±0,15	1,39±0,11	1,36±0,13	1,59±0,14	1,39±0,13
Methionine	0,21±0,02	0,23±0,04	0,27±0,04	0,34±0,03	0,26±0,03
Tyrosine	0,63±0,06	0,95±0,05	0,75±0,04	0,83±0,06	0,79±0,05
Phenylalanine	0,69±0,04	0,83±0,05	0,80±0,04	0,64±0,04	0,74±0,04
Cystine	0,42±0,04	0,65±0,05	0,69±0,05	0,66±0,04	0,61±0,05
Aspartic acid	0,19±0,03	0,17±0,04	0,18±0,04	0,29±0,05	0,21±0,04
Glutamic acid	1,50±0,12	1,37±0,11	1,50±0,11	1,57±0,12	1,49±0,12
Proline	1,94±0,13	1,96±0,12	2,46±0,12	1,85±0,14	2,05±0,13
Glycine	1,14±0,13	1,47±0,11	1,80±0,12	1,38±0,10	1,45±0,12
Alanine	2,02±0,18	2,39±0,17	2,39±0,16	2,27±0,17	2,27±0,17
Lysine	1,60±0,17	2,75±0,15	2,36±0,16	2,36±0,18	2,27±0,17
Histidine	0,75±0,09	1,12±0,08	0,99±0,07	1,00±0,09	0,97±0,08
Arginine	0,98±0,08	1,05±0,09	0,70±0,10	1,33±0,10	1,02±0,09

Table 2. Free amino acid content (mg%) in human blood plasma

Amino acid	Reference			
	[3]	[6]	[1]	[4]
Isoleucine	0,69–1,28	0,46–1,15	0,5–1,00	1,05±0,05
Leucine	1,42–2,30	0,93–1,78	1,00–3,00	2,03±0,08
Valine	2,37–3,71	1,36–2,66	1,50–3,00	2,54±0,06
Threonine	1,21–1,72	1,22–2,93	1,00–3,00	1,91±0,09
Serine	1,01–1,25	0,68–2,03	1,00–2,00	2,02±0,09
Methionine	0,33–0,43	0,23–0,39	0,3–0,7	0,54±0,04
Tyrosine	0,82–1,45	0,65–1,14	0,6–2,00	1,04±0,06
Phenylalanine	0,69–0,95	0,63–1,92	0,5–2,00	1,13±0,06
Cystine	1,08–1,30*	1,15–3,37	1,00–3,00	0,91±0,10
Aspartic acid	0,01–0,07	trace 0,72	2,00–5,00	0,07±0,05
Glutamic acid	0,43–1,15	0,25–1,73	0,7–4,00	3,97±0,26
Proline	2,01–3,34	1,28–5,14	0,5–3,00	2,76±0,08
Glycine	1,34–1,73	1,08–3,66	1,00–4,00	2,32±0,39
Alanine	3,01–3,73	2,22–4,47	2,00–4,00	3,80±0,14
Lysine	2,52–3,02	2,11–3,09	1,00–4,00	3,22±0,15
Histidine	0,79–1,48	0,97–1,45	1,00–3,00	1,64±0,08
Arginine	1,22–1,93	0,86–2,63	0,8–2,00	1,07±0,08

*Cystine + cysteine.

Results and Discussion

Table 1 lists the data obtained on levels of free amino acids in cosmonauts' plasma. It also shows the seasonal fluctuations of the same parameters. Table 2 lists, for the sake of comparison, data from the literature suggested as the conventional physiological norm for healthy humans. The results of assaying plasma levels of free amino acids at different seasons revealed that, regardless of season, there was virtually no change in amino acid composition of cosmonauts' plasma, so that the quantitative composition of amino acids contained in blood, which we suggest, may be considered the physiological norm for cosmonauts (n = 141). It must be noted that there are many published norms for the amino acid spectrum of blood plasma, but none of the proposed standards took into consideration the specifics of cosmonauts' work. Moreover, data are often submitted with a wide range of scatter which, of course, makes it difficult to detect genuine deviations from the norm [1, 3, 4, 6]. A comparison of the physiological norm for cosmonauts which we derived to the norm cited by N. V. Semenov shows that for the cosmonauts the levels of threonine, aspartic and glutamic acids were above the top of the normal range during their preflight training [3], against a background of low alanine level. At the same time, if we were to be guided by the data of Muller [6] and I. S. Balakhovskiy [1], the concentrations of the above-mentioned plasma amino acids are within their proposed range of fluctuations. In the last two references, obviously high values are cited for aspartic and glutamic acids. This is apparently due to the fact that, in the course of analysis, these amino acids are eluated concurrently with their amides--asparagine and glutamine, respectively--and the cited values are overall levels. We previously had also tried to derive a physiological norm for free amino acids in blood plasma of a normal person under hospital conditions and controlled diet (n = 80, average weight 70.5±0.7 kg, height 173.0±1.0 cm, age 25-35 years) [4]. A comparative analysis of that norm [4] in relation to the one obtained here for cosmonauts during preflight training confirmed once more the need to derive a "specific" norm for the category of individuals whose activities involve intensive training. Thus, the levels of most amino acids in blood plasma of a healthy person exceeded those demonstrated for cosmonauts, with the exception of threonine and aspartic acid. Moreover, we analyzed total free amino acids in human plasma (Table 3). It can be concluded from the listed results that the physiological norm derived for cosmonauts for total essential (E) and nonessential (N) amino acids is within the range of fluctuation of conventional norms; however, there is a difference in E/N ratio. This ratio was comparable to our data only in the work of N. V. Semenov.

Table 3. Overall parameters of blood plasma free amino acids (mg%)

Parameter	Reference				Our preflight data
	[3]	[6]	[1]	[4]	
Total essential amino acids (E)	9,35 - 13,80	6,94 - 13,9	16,4 - 48,7	12,42	9[illegible]
Total nonessential amino acids (N)	11,63 - 17,20	9,14 - 26,30	10,6 - 32,0	19,66	12[illegible]
Total amino acids	20,98 - 31,00	16,08 - 40,20	27,0 - 80,0	32,08	22[illegible]
E/N ratio	0,80 - 0,80	0,76 - 0,53	1,53 - 1,52	0,63	0[illegible]

It is expected that the physiological norm for plasma free amino acid levels in cosmonauts during their preflight training period, which we derived in this study, will make it possible to assess more objectively, in the future, the results obtaine ıfter they are exposed to spaceflight factors.

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LBNP TRAINING OF CREW MEMBERS ON MAIN MISSIONS ABOARD SALYUT-6 ORBITAL STATION

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 6, Nov-Dec 84 (manuscript received 22 Jun 83) pp 29-33

[Article by V. M. Mikhaylov, Yu. D. Pometov and V. A. Andretsov]

[English abstract from source] This paper describes the protocols of LBNP training of five prime crews that flew onboard Salyut-6. It is indicated that LBNP is one of the major constituents of countermeasures that must be performed inflight. LBNP may help adapt to weightlessness-induced blood redistribution and predict the level of postflight orthostatic tolerance.

[Text] A number of preventive measures have been proposed to prevent deconditioning of the cardiovascular system during spaceflights, and among them an important place is given to the use of negative (i.e., subatmospheric) pressure on the lower half of the body (LBNP). At the present time, this method is used extensively in space and sports medicine, as well as clinical practice [1, 8, 10, 12].

In space medicine, LBNP is used mainly in two modifications: as a functional test [3-5] and as a training procedure [6, 9, 11].

Methods

A set of preventive measures was developed for use during flights aboard the Salyut-6 orbital station, which included LBNP conditioning in a pneumovacuum suit--PVS [2], which was submitted to additional trial in studies involving 182-day antiorthostatic [head-down tilt] hypokinesia (AOH) [7]. The results of the tests revealed that the proposed preventive measures were sufficiently reliable, and this served as grounds for using them during the main missions aboard Salyut-6.

Results and Discussion

First main mission. LBNP was used for conditioning for the last 5 days of the flight following the protocol illustrated in Figure 1. The structure of LBNP training on the 1st day consisted of two microcycles lasting a total of 60 min and on the 2d-5th days, three cycles lasting a total of 90 min.

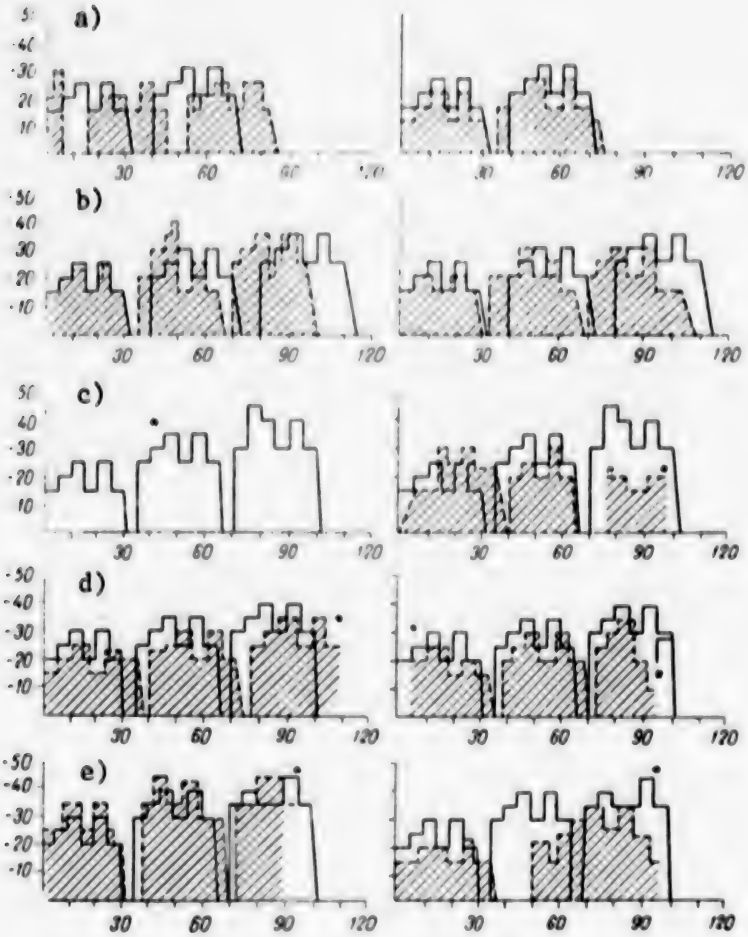

Figure 1. Recommended (solid line) and actually followed (dash line) LBNP conditioning programs of crew members on first main mission aboard Salyut-6

Left: data for CDR Right: data for FLE

a-e) first to fifth days *No telemetry data

During the training, the crew members checked on themselves and each other. It was recommended that they step from foot to foot, simulating walking in place. In addition, they were to take 300 mℓ fluid 20-30 min before each training session.

At the last stage of the flight, both cosmonauts performed the scheduled volume of exercise with LBNP. Overall volume of conditioning according to levels of rarefaction and duration of LBNP was close to the planned amount (see Figure 1). Total conditioning time was 425 min for the commander (CDR) and 403 min for the flight engineer (FLE), the program calling for 420 min. The FLE reduced somewhat his conditioning time at high rarefaction (30.35 and 40 mm Hg), eliminated 45 mm Hg and, at the same time, extended somewhat exercise at 20 and 25 mm Hg. Thus, he had used a more conservative mode of LBNP. Objectively, both crew members endured the conditiong quite satisfactorily and they presented no complaints of poorer wellbeing during use of LBNP. The performed amount of conditioning with LBNP conformed on the whole with the set goals.

Second main mission. At the final stage of the second main and subsequent missions it was decided to modify and expand the overall program for using LBNP. Instead of one-stage (5-day) conditioning, there was training in two stages starting 18 days before the end of the mission. This was done on the basis of the findings, the crew's wishes and experience gained during the long-term missions of American astronauts aboard the Skylab orbital station. At the first stage, the crew performed preliminary training and at the second, the basic conditioning with LBNP. This approach provided for gradual adaptation to gravity-induced redistribution of blood, made it possible to obtain additional data for forecasting orthostatic tolerance of the crew during the mission and its change under the influence of LBNP training, as well as to prepare proper programs and individual protocol for LBNP conditioning with consideration of the crew's physiological reactions.

In planning the training exercises, the goal was to adhere to continuity in grading levels and order of change in rarefaction in order to gain objective telemetry information about the crew's physiological reactions.

First stage (preliminary training). Preliminary LBNP training was scheduled for the 18th, 14th, 10th and 6th days before the end of the mission on every 4th day of the physical exercise cycle (day of active rest), for 20 min at rarefaction of 10 to 35 mm Hg in the 1st cycle (18 days before landing), 15 to 40 mm in the 2d (L-14), 25 to 45 mm Hg in the 3d and 4th (L-10 and L-6). The crew consumed 10-12 sips of fluid 20-30 min before training and they stepped from foot to foot 12-14 times/min with LBNP.

On the whole, there were insignificant deviations from the planned programs of preliminary LBNP conditioning. In the 1st cycle, the CDR exceeded the specified rarefaction in the PVS by 5-15 mm Hg; in the 4th cycle he used 5-10 mm Hg less rarefaction than planned. The FLE extended training time by 5 min due to the need to collect telemetry information.

At the first preparatory stage, total exercise time was 78 min for the CDR and 85 min for the FLE (the recommended time being 80 min). Heart rate ranged from 88 to 96/min and 98 to 105/min at 35 and 40 mm Hg for the CDR and, under analogous conditions from 87 to 92 and from 93 to 102/min, respectively, for the FLE. Considering their good tolerance of the preliminary conditioning exposure to LBNP, it was decided to limit it to 2 days at the final stage.

Second stage (main training). For the last 2 days of the mission (138th and 139th days), the crew submitted to LBNP for 55 min as illustrated in Figure 2. At the second stage of main conditioning, both crew members trained for less time than scheduled. Thus, instead of 110 min, the CDR submitted to LBNP for only 84 min, reducing the time at all levels of decompression. The FLE trained for a somewhat longer time, 96 min, having reduced the time of the 10-min plateaus of decompression. Heart rate at 45 mm Hg rarefaction reached 115/min for the CDR and 95/min for the FLE.

The LBNP training did not elicit any comments by the cosmonauts during the flight. According to their radio transmissions, their wellbeing remained good throughout the exposure time. They were somewhat more impressed by the training on the 139th day than the 138th. Thus, the CDR reported sensations

of blood rushing from his head, while the FLE reported signs of adaptation to LBNP, after which weightlessness was again perceived as an unusual state. These signs had also been observed previously in cosmonauts when using LBNP conditioning during shorter missions aboard Salyut-6.

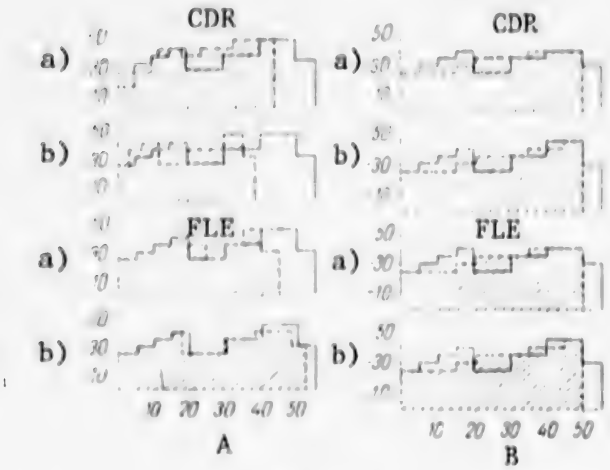

Figure 2.
Recommended (solid line) and actually followed (dash line) programs of main LBNP training for crews of second (A) and third (B) main missions aboard Salyut-6
a, b) 1st and 2d days, respectively

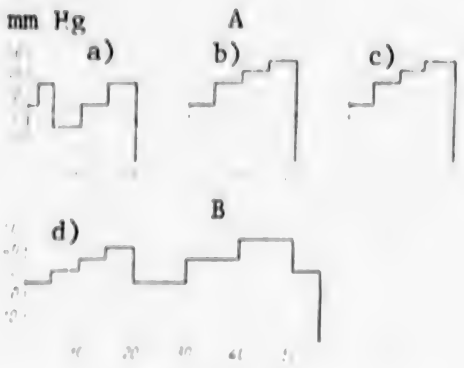

Figure 3.
Programs of preliminary (A) and main (B) LBNP training for crew of fourth main mission aboard Salyut-6 (recommendations)
a-d) 174th, 178th, 181st, 184th-185th days, respectively

The cosmonauts' self- and mutual-checks, as well as availability of telemetry information about tolerance to LBNP, rendered the conditioning exercises safe and, in conjunction with other preventive measures, were instrumental in adequate orthostatic tolerance and performance in the postflight period.

Third main mission. At the final stage of the third main mission, virtually the same two-stage program of LBNP training was used as during the second main mission aboard Salyut-6. In both instances, LBNP conditioning was so planned as to have crew members adhere to mutual checks and at the "plateaus" of 25, 35 or more mm Hg it coincided with the telemetry sessions. This approach assured the safety of the procedures and made it possible to individualize the training process in accordance with tolerance.

First stage (preliminary training). LBNP was used, as a rule, on the 4th day of the physical exercise cycle (day of active rest) 21, 13 and 8 days (154th, 162d and 167th days, respectively) before the end of the mission, for 20 min at a time (total 80 min).

On the whole, the cosmonauts performed the entire planned volume of conditioning. Total training time was 81 min for the CDR and 85 min for the FLE. As for the levels of rarefaction used, they were more variable, particularly for the FLE. Successful use of preliminary LBNP made it possible to recommend a 2-day conditioning schedule at the final stage of the flight.

Second stage (main training). In the final period (173d and 174th days), the crew submitted to LBNP for 55 min/day following the protocol illustrated in Figure 3. At this stage, the cosmonauts adhered more precisely not only to the time intervals, but levels of rarefaction in the PVS. There was good tolerance of the recommended modes of LBNP conditioning. Thus, the commander's heart rate was in the range of 60-78/min at 35 mm Hg and 67-82/min at 40 mm Hg. In the FLE, it reached 91/min at 35 mm Hg and was in the range of 79-94/min at 40 mm Hg rarefaction. The obtained telemetry information was indicative of a normal cardiovascular reaction to this factor, which is apparently what determined to a large extent the crew's postflight orthostatic tolerance.

Fourth main mission. Preliminary LBNP training (1st stage) was scheduled for L-18, L-14, L-10 and L-6, 20 min at a time, while the main (second) stage called for 55 min/day on the last 2 days of the mission (185th and 186th days). Because of the insufficient flight time, it was decided to omit one of the preliminary training sessions (see Figure 3). In addition, the first session on the 184th day of the mission coincided with a functional LBNP test (rarefaction of 25 and 35 mm Hg for 2 and 3 min, respectively).

The first 2 preliminary training sessions (174th and 178th days) were performed by the crew in their entirety. However, on the 179th day the CDR complained of pain in his leg muscles during physical exercise. The pain did not disappear on subsequent days. For this reason, the CDR did not undergo any further LBNP conditioning. The FLE submitted to the entire planned training sessions. In the CDR, the heart rate rose from 78 to 83 and 88/min during the first training session (174th flight day) at 25 and 35 mm Hg, respectively. During the second training session (178th flight day) at 45 mm Hg rarefaction, it reached 108/min. In the FLE, the heart rate ranged from 63 to 80 at 25 mm Hg and 66 to 82/min at 35 mm Hg (base value being 54-78/min), from 82 to 87 at 40 mm Hg and 78 to 96/min at 45 mm Hg.

The favorable reaction of the cardiovascular system of both crew members to LBNP during the final stage of the mission aboard Salyut-6, as well as their performance of other elements in the set of preventive inflight measures, made it possible to offer a favorable forecast on the course of postflight recovery. A milder course of the recovery period was predicted for the FLE.

Fifth main mission. In view of the heavy work load and relatively short duration of the spaceflight, as compared to the preceding ones, the crew of the fifth main mission underwent LBNP conditioning with the following modifications: the 1st, 2d and 3d cycles of preliminary training were eliminated; one training session for familiarization purposes occurred 3-4 days before landing, which was combined with a functional LBNP test.

It was assumed that, in the case of good tolerance, the main 2-day training sessions would follow a regular protocol and, in the case of satisfactory tolerance, an individual one.

The crew tolerated satisfactorily the prelimiary LBNP training session. They performed close to the planned protocol for this training. Maximum pulse rate was found in the CDR at 45 mm Hg rarefaction--106/min (72/min was the base value), whereas in the FLE it was 113/min (75/min initially). In view

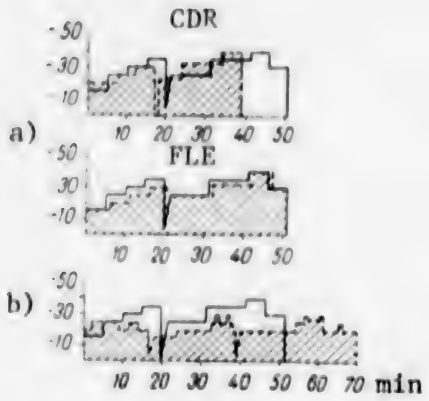

Figure 4.
Protocol of main LBNP training sessions for crew of fifth main mission aboard Salyut-6
a, b) 1st and 2d days, respectively

of the rather marked increase in pulse rate of both cosmonauts, it was recommended not to use more than 40 mm Hg in the PVC for the main conditioning sessions.

As can be seen in Figure 4, the crew performed the entire planned amount of LBNP training on the 1st day on the main training program. However, the CDR did so for 40 min instead of 50. There was satisfactory tolerance. At 40 mm Hg rarefaction, pulse rate was 115/min for the CDR and 98/min for the FLE. On the 2d day of the cycle, CDR did not undergo the training session while the FLE performed it in full. Analysis of the rarefaction conditions recorded on the automatic memory device indicated that the FLE trained for 20 min more than was planned and did not set high levels of rarefaction, i.e., he used a "softer" mode of LBNP.

It can be hoped that this use of LBNP in a training mode was instrumental, to some degree, in activating the regulatory mechanisms of the cardiovascular system that are responsible for circulatory homeostasis in erect position and attenuated the adaptation process in earth's gravity.

In conclusion, we must stress the importance of using the set of inflight preventive measures, one of the elements of which is LBNP, which are aimed both at adapting man to gravitational redistribution of blood and forecasting orthostatic tolerance of crews in the postflight period.

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*Translator's note: The "Ibid" may refer to KOSMICHESKAYA BIOLOGIYA, but obviously does not refer to preceding reference.

UDC: 612.13+612.17]-087

MAIN COMPONENT METHOD USED TO STUDY VARIATIONS OF CARDIOVASCULAR PARAMETERS

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 6, Nov-Dec 84 (manuscript received 25 Aug 83) pp 33-37

[Article by A. D. Voskresenskiy, N. I. Vikhrov, A. P. Varnashenko, V. G. Doroshev, Z. A. Kirillova, M. A. Matrosova and S. L. Chekanova]

[English abstract from source] The main component method was used to analyze measurements of cardiovascular parameters taken in 14 healthy operators at rest. The entire sample included 237 observations. Each observation was characterized by the deviation of heart rate, mean blood pressure and stroke volume from individual data points. The latter were individual mean values of the above parameters recorded during the Valsalva maneuver. The first two main components were responsible for over 77% of total variance of signs. Visual analysis of observation distribution with respect to the components revealed small group and single data points situated peripherally at a distance from the major constellation of data points. With respect to the values in these groups it can be assumed that some of them correspond to the stressed state of the cardiovascular system. Two thirds of data points in the stressed groups are associated with the subjects who show a weak reaction to the Valsalva maneuver and one third corresponds to the true stressed state. Taking into account the Valsalva maneuver, the deviations from individual data points can be used to identify the stressed state of the cardiovascular system in heatlhy men at rest.

[Text] The parameters of the cardiovascular system of healthy people fluctuate widely, even in groups that are similar in age and occupation [1]. For this reason, it is ineffective to use the ranges of the "group norm" to assess the results of examining operators [7]. More effective criteria can be found by different means. One of the approaches is based on development of theory of "individual norm" [6, 7], another implies that it is possible to single out narrower classes of the norm, which reflect different types of regulation of physiological functions or existence of states bordering on pathology [2, 3]. Finally, a combined approach is possible, with which the classes of normal or borderline states are formed according to extent of deviation of physiological parameters from the chosen individual reference points. This approach was

used here for analysis of the results of repeated examination of healthy operators at rest. The objective was to study the possibility of classifying cases according to several parameters in the absence of independent criteria for determining the class. Such tasks require use of special methods of multidimensional statistics. In this case, we used the method of main components [4, 5].

Methods

We analyzed the results of repeated measurement of cardiovascular parameters of 14 operators. The total observation period lasted about 3 months. The sample of base data consisted of 237 cases at rest and results of 53 graded Valsalva maneuvers (30 mm Hg pressure, duration 30 s). We analyzed the heart rate (HR), mean blood pressure (BP_m) and stroke volume of the heart (SV). As individual reference points we used the average values of parameters for an individual during the Valsalva maneuver. Thus, each case could be described by a set of three absolute parameters (HR, BP_m, SV) and three values for deviations from individual reference points (ΔHR, ΔBP_m, ΔSV). Our experience with factor analysis of physiological data led us to expect that the first two factors would be responsible for 70-80% of overall variance of signs. In this case, the entire sample of cases could be represented by points on a plane in a system of f_1 and f_2 coordinates. For this reason, it is possible to visually assess the distribution of points and detect special groups of interest for further analysis. These considerations were involved in selecting the method of analysis. The calculations were made following standard programs for data processing [8].

Results and Discussion

Table 1 lists mean values and standard deviations (SD) of parameters for the entire sample of 237 cases at rest. As can be seen in this table, there was a rather wide range of variation of parameters. Thus, within two SD from mean values, the range constituted 47-92/min for HR, 79-114 mm Hg for BP_m and 39-116 mℓ for SV.

Table 1. Statistical characteristics of initial sample of data obtained at rest (n = 237)

Parameter	HR/min	BP_m, mm Hg	SV, mℓ
Absolute values	69.8±11.5	96.6±8.61	77.6±19.46
Deviations from individual reference points	-16.3±12.0	-5.5±10.39	9.8±17.39

At the first stage of our study, we explored the possibility of classifying the cases according to the set of absolute values of parameters. The first 2 factors determined 82% of total variance of signs, which enabled us to consider the distribution of cases according to values of f_1 and f_2 (Figure 1). As can be seen in this figure, there is gradual decrease in density of points

from the center of the coordinates to the periphery. Visually, we could not distinguish any separate groups of cases. Then, using the method of main components, we analyzed deviations from individual reference points. The first two factors determined 77% of total variance. The distribution of cases in the system of f_1 and f_2 coordinates is illustrated in Figure 2. Unlike the distribution illustrated in Figure 1, most of the points here are more compactly arranged around the center of coordinates and the region of relatively high point density forms a figure that is close to a circle with a radius of about 1.6. Around this region, at some distance from it there are small scattered groups of points and a few single points (in Figure 2, these peripheral findings are marked with crosses, while the groups of peripheral points are outlined with dashes). Thus, a comparison of distributions in Figures 1 and 2 warrants the assumption that use of deviations from individual reference points improves somewhat the possibility of classifying cases.

Figure 1.
Distribution of cases according to values of two first main components with use of set of absolute values of parameters

Figure 2.
Distribution of cases according to values of first two main components with use of deviations of parameters from individual reference points. Explained in the text

Apparently, expressly the peripheral groups of points are of interest for further analysis, since they could reflect the presence of classes of borderline states or rare variants of the "norm." We took all of the case numbers, the distance of which to the coordinate center exceeded 1.6, in order to interpret physiologically the distribution illustrated in Figure 2. The selected cases were grouped in quadrants. Determination was made of the range and means of parameters in each group (Table 2).

Table 2. Characteristics of peripheral groups of cases in quadrants

Parameter	Quadrant			
	upper left	upper right	lower right	lower left
ΔHR/min	−33,2 [(−12)−(−52)]	−19,3 [(−7)−(−38)]	4,65 [14−(3)]	−11,1 [7−(−32)]
ΔBP_m, mm Hg	−16,0 [2−(−31)]	−21,4 [(−17)−(−29)]	1,1 [15−(−13)]	7,1 [32−(−11)]
ΔSV, mℓ	24,55 [4−50]	−9,4 [3−(−21)]	−5,2 [8−(−31)]	40,9 [67−11]

Note: Here and in Table 3, the range of fluctuations is given in parentheses.

The group of peripheral cases in the left upper quadrant was characterized by drastically reduced HR, as compared to individual reference points, significant decline of BP and significant increase of SV. This group of cases seemed to stress the consistent differences between functional stress of the cardiovascular system during the Valsalva maneuver and quiet state. The peripheral cases in the right upper quadrant can also be classified as a quiet state, although the decline of HR in relation to individual reference points was less marked here, while SV was somewhat lower on the average than during the test. The groups of points and individual points on the peripheral of the right lower quadrant turned out to be more interesting. Of the 17 cases over 1.6 away from the center of coordinates, 14 were characterized by higher HR than during the Valsalva maneuver and 13, by lower SV. BP_m deviated in different directions and its average value was close to the one during Valsalva's maneuver. Evidently, from the formal point of view, this group can be interpreted as a state of functional stress of the cardiovascular system. The group of cases on the periphery of the left lower quadrant occupies an intermediate position between quiet and stress. In this group, SV was considerably higher than the individual reference points; however, HR was substantially less decreased than the average for the sample, while BP_m was higher than during the Valsalva maneuver in 13 out of 16 cases. Thus, this group of cases can be characterized as a state of moderate stress of the hypertensive type.

From the practical point of view, it is important to determine the extent to which formation of "tension" [or stress] groups is caused by distinctions in position of individual reference points. Apparently, when an individual reference point is close to the mean value of a parameter in a quiet state, the resting values will very probably deviate from it in both directions, including the direction functional "stress" of the cardiovascular system. It could be expected that individuals with mild reaction to the Valsalva maneuver will have a greater chance of being in the "stress" group than those with a well-marked reaction. To check this hypothesis, the method of main components was used to process data obtained from 53 Valsalva tests. As a result, groups of cases were singled out that characterize strong, mild and two intermediate reactions to the Valsalva maneuver. The characteristics of these groups are listed in Table 3.

Table 3. Characteristics of different types of reactions to Valsalva maneuver

Group	Reaction	HR/min	BPm, mm Hg	SV, mℓ	ΔHR/min	ΔBPm, mm Hg	ΔSV, mℓ
1	Strong (n= 12)	93,6 (62–112)	110,2 (93–134)	54,4 (35–75)	20,8 (–2–37)	24,4 (10–58)	–23,1 [(–8)–(–42)]
2	Medium (n= 18)	82,0 (62–120)	94,0 (79–105)	58,2 (44–83)	(16,8) (–5–45)	6,4 (–6–17)	– 20,0 [0–(–37)]
3	Medium (n= 6)	92,7 (67–113)	109,8 (98–128)	79,0 (61–100)	16,5 (6–32)	16,3 (9–41)	5,0 (–6–14)
4	Mild (n= 17)	72,8 (52–98)	96,0 (86–115)	86,1 (64–124)	6,8 (–5–17)	1,7 (–17–12)	–0,2 (–13–27)

Analysis of the distribution of individual data for these groups revealed that there was overt prevalence of mild reactions in 3 subjects (see Table 3, group 4) and in 2 others there were alternately mild and medium reactions. None of these 5 people presented a reaction that could be called strong (see Table 3, group 1). The other 9 subjects presented only strong or average reactions. It was found that 23 cases of "stress" at rest were referable to the first 5 people and only 10 to the others. In relation to the number of studies performed at rest, in the group of subjects with mild reaction 24.2% were referable to stress cases, whereas this applied to 7.04% of those with strong or medium reaction. The difference in share of cases was statistically reliable ($P<0.01$).

Thus, formation of "stress" groups is determined, in approximately two-thirds of the cases, by individual distinctions of reaction to the Valsalva maneuver. The probability of falling into the "stress" group according to resting data is more than 3 times higher for subjects with mild reaction than those with strong or medium reaction. At the same time, almost one-third of the "stress" group consists of cases that cannot be attributed to the position of individual reference points. They can be considered cases of genuine functional stress of the cardiovascular system. Consequently, with consideration of the reaction to the Valsalva maneuver, the deviations from individual reference points can be used to detect cases of functional stress of the cardiovascular system at rest.

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ROLE OF MENTAL WORK IN HUMAN TOLERANCE TO TOTAL-BODY VIBRATION

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 6, Nov-Dec 84 (manuscript received 16 Jun 83) pp 37-40

[Article by Yu. N. Kamenskiy]

[English abstract from source] Phasic changes of psychophysiological parameters developed in response to vibration of 10 Hz and acceleration of 1 m/s^2 for 1 h. During the first phase some parameters decreased and others increased. Later all psychophysiological parameters significantly decreased. Circulation parameters tended to decline during exposure. The psychophysiological changes were less expressed in the test subjects normally involved in mental work. This suggests that mental workers have higher tolerance to vibration effects.

[Text] Much attention is given to investigation and setting hygienic standards for total-body vibration [3, 6, 7]. However, some important aspects of this question, in particular the role of mental (operator) work in human reactions to total-body vibration, have not yet been sufficiently covered in the literature. Under actual working conditions, operators are exposed to vibration when performing specific work, which may alter their reactions to the vibration factor and plays the role of a distracting factor. Conversely, the absence of such distraction under experimental conditions could lower man's tolerance to vibration [1]. In order to define the role of mental work in man's reactions to vibration we conducted this investigation.

Methods

Two series of studies were conducted: I--with exposure to vibration at a frequency of 10 Hz and acceleration of 1.0 m/s^2 for 1 h; II--with vibration of the same parameters during mental work. Psychological form tests were used as a model of mental work: "search for patterns" and cancellation test (Landolt circles). Sinusoidal vertical vibrations were generated by a VEDS-200A vibration-testing machine. The parameters of vibration were controlled with low-frequency vibroacoustic equipment in accordance with GOST 13731-68. The subject sat on a hard chair. A total of 10 essentially healthy men ranging in age from 25 to 44 years, whose occupations were unrelated to exposure to vibration, participated in the study. They participated twice in each series of studies. A total of 40 studies were performed.

Dynamics of psychophysical parameters with exposure to vibration (1) and vibration with mental work (2), M±m

Parameter	Series	Background	Exposure, min					Aftereffect period, min		
			5	15	30	45	60	5	15	30
CFF, Hz	1	32.9±1.3	27.8±1.6*	27.7±1.7*	26.9±1.8*	27.2±1.6*	28.3±1.6*	32.4±1.5	32.5±1.4	32.7±1.5
	2	34.0±1.8	28.4±1.9*	28.5±1.9*	28.7±2.1*	28.9±2.2*	29.1±2.2*	32.9±1.9	33.9±1.9	33.8±1.7
PCM, AU	1	2.9±0.2	1.9±0.5*	1.7±0.3*	1.5±0.3*	1.8±0.6*	1.6±0.3*	3.1±0.2	2.9±0.1	3.2±0.3
	2	3.2±0.8	2.1±0.4*	2.1±0.2*	2.5±0.4*	2.1±0.4*	2.3±0.7*	3.8±0.5*	4.0±0.5*	4.7±0.6*
RME, AU	1	3.5±0.4	3.7±0.5	2.1±0.3*	2.7±0.5*	2.9±0.3*	3.0±0.7	4.5±0.5*	3.2±0.3	3.7±0.7
	2	3.0±0.4	3.4±0.4	2.6±0.4	3.0±0.7	3.1±0.4	3.0±0.4	3.9±0.7*	4.0±0.6*	4.8±0.4*
PNP, AU	1	1.10±0.22	0.82±0.13*	0.76±0.11*	0.84±0.10*	0.89±0.15*	0.89±0.10*	0.86±0.16*	0.87±0.11*	0.94±0.11*
	2	1.35±0.13	1.08±0.11	1.06±0.18	1.05±0.18	1.07±0.17	0.97±0.14*	0.89±0.10*	0.91±0.20*	0.78±0.07*

* $P<0.05$ in relation to background values. AU) arbitrary units

The following psychophysiological methods were used: critical fusion frequency (CFF), reproduction of muscular exertion (RME), precision of coordination of movements (PCM) and reaction to moving object (RMO). The results of the RMO were assessed from the ratio of number of premature reactions (RMO_p) to number of delayed reactions (RMO_d), which was arbitrarily called the parameter of nervous processes (PNP). We measured systolic (BP_s) and diastolic (BP_d) arterial pressure, and counted the heart rate (HR) on the ECG. Statokinetic stability was evaluated from stabilometry data. The subjects were examined before exposure (background), during 1st-5th, 15th-20th, 30th-35th, 55th-60th min of exposure and in the 1st-5th, 15th-20th, 25th-30th min of the aftereffect period. The data were submitted to statistical processing under the condition of 95% reliability of differences between mean values.

Results and Discussion

Some of the subjects in both series of tests reported a feeling of instability right after the vibration machine was stopped, but it disappeared within the first few seconds of the aftereffect period. They also reported general fatigue and heaviness of the legs. The absolute majority of subjects (9 out of 10) believed that vibration is tolerated better during mental work, since it distracts them from vibration. In the second series of tests there were no cases of sleepiness, whereas in the first series 4 subjects became sleepy in the 15th-30th min of exposure. Statokinetic stability did not worsen in either series, in spite of some cases of brief feeling of instability after exposure.

During exposure, the dynamics of change in some parameters (CFFM, PCM) were the same in both series and in others (RME, PNP) they differed (see Table). A common finding was the phasic nature

of changes in most parameters. Thus, CFF and PCM dropped drastically in both series at the very start, remained low during exposure and were virtually entirely restored immediately after exposure to vibration. The identical changes in CFF and PCM were due to the fact that these parameters were subject to the direct mechanical effect of vibration. As it was transmitted to the subject's hand, vibration intensified tremor, as a result of which PCM diminished. Evidently, the decline of CFF was due to interaction of three oscillatory processes: bioelectric (cortical part of the visual analyzer), photic (flickering light) and mechanical (oscillation of the head, eyeballs and hand of the subject). The virtually complete recovery of PCM and CFF immediately after exposure to vibration confirms the biochemical nature of these changes. Obviously, mental work was a comparatively indifferent factor in relation to PCM and CFF and for this reason did not have a substantial influence on extent and nature of changes in these parameters.

Vibration did not have a direct mechanical effect on RME and PCM parameters; for this reason, the dynamics of these parameters depended only on the functional state of the body and were more complex. At the very start of exposure RME improved somewhat and PNP worsened in both series of tests. These changes can be viewed as the body's primary reaction to exposure. The initial improvement of RME could be related to the subjects' psychological set for good performance of their assignment, although such a set was not present in all cases. Individual analysis revealed that RME changed in the same number of cases in both series at the start of exposure: it worsened in 3 cases, improved in 3 and was unchanged in 4. By the middle of the exposure period RME worsened in all of the first series subjects, but was virtually completely recovered by the end of the exposure period; in the second series, RME showed virtually no change during exposure, with the exception of an initial shift; PNP decreased at the start of exposure in 3 subjects of the first series and 4 of the second series; in the rest, there was no change in PNP. On the average, the PNP decline was reliable only in the first series of tests. Such an initial decline of PNP could be interpreted as the result of the distracting effect of vibration, as a result of which the subjects' reaction to a moving pointer slowed down and there was an increase in number of RMO_d. In the first series, PNP remained reliably lower than the base value for the entire exposure period; in the second series, the shift of PNP in the direction of decline reached a reliable level only by the end of the exposure time. Since the decline of PNP occurred in both series because of decrease in number of RMO_p and increase in RMO_d, this can be evaluated as the result of intensification of an inhibitory process in the central nervous system (CNS) caused by vibration. It is known that vibration enhances inhibition in the CNS to the extent of sleepiness [2, 5]. Less marked inhibition in the second series of subjects could be due expressly to the distracting effect of mental work. Evidently, greater resistance of operators to vibration under actual industrial conditions than in the laboratory is related to this distracting effect of their work [4].

The dynamics of changes in autonomic parameters were the same in both series: HR had a tendency toward decrease, BP_s dropped insignificantly and BP_d rose. These identical changes were due to the absence of a significant emotional element in the work done by the subjects.

Consequently, exposure to total-body vibration at a frequency of 10 Hz and acceleration of 1 m/s^2 for 1 h elicits changes in a number of psychophysiological and autonomic parameters of man, which are phasic in nature. Mental work distracts the subjects from the effect of vibration, causes some degree of operational tension and thus is instrumental in increasing tolerance to this factor.

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HUMAN LUNG FLUID CONTENT DURING 7-DAY HEAD-DOWN TILT

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 6, Nov-Dec 84 (manuscript received 27 Sep 82) pp 40-44

[Article by E. M. Nikolayenko, V. Ye. Katkov, S. V. Gvozdev, V. V. Chestukhin, M. I. Volkova, M. I. Berkovskaya and T. G. Kediya]

[English abstract from source] The time-course variation of the water content of the lungs of seven male volunteers were examined during 7-day head-down tilt (at -15°). As compared to the horizontal subjects, the tilted subjects showed a significant increase in the water content from 557±19 mℓ to 612±63 mℓ by the 7th hour of the tilt. Later on the parameter gradually declined and on tilt day 7 almost returned to the pretest level, i.e., 567±46 mℓ. This increase in the water content during the first hours of the exposure can be attributed to the hydrostatic factors: higher pulmonary artery pressure and higher cardiac output. The increase in the water content on tilt days 3-7 can be associated with changes in the permeability of lung capillaries, drainage function of the lymphatic system of the lungs and colloidal-osmotic pressure in the perivascular space of the lungs.

[Text] The efficiency of pulmonary gas exchange and oxygenation of arterial blood depend largely on distribution of ventilation-perfusion ratios in the lungs. The uneven ventilation-perfusion ratios in healthy people are related to the vertical gradient of pleural and intrapulmonary pressure due to gravity forces, filling with blood and hydration of the lungs [16].

It has been shown that changes in vector and force of gravity have a substantial effect on distribution of blood flow in the pulmonary circulatory system [5, 12, 17] and, consequently, ventilation-perfusion relations and gas exchange in the lungs. However, no studies have been made of the effect of these changes on fluid levels in lung tissue, which influence substantially biomechanics of respiration and gas exchange.

Our objective here was to investigate the changes in lung fluid content when man is exposed to an altered vector of gravity forces--7-day antiorthostatic [head-down tilt] hypokinesia (AOH) with the body inclined at an angle of -15°.

Methods

This study was conducted with the participation of 7 healthy male volunteer subjects (age 33.3±5.2 years, height 178±6 cm, weight 75.1±10.2 kg). The functional parameters of their lungs are listed in the Table. A few days before the tests, a Swan-Ganz (Edwards 93A-131-7F) catheter was implanted in the pulmonary artery under local anesthesia, using a previously described technique [2], and a thin-walled cannula (Medicut Sherwood G-20) was inserted in the radial artery, for recording pressure and drawing blood samples for analysis of gases.

Functional parameters of lungs of group of healthy subjects in supine position

Subject	TLC	VC	FRC	RV	RV/TLC, %	mPAP, mm Hg (kPa)
	% nominal functional values					
1	98	100	125	86	26	14 (1,9)
2	105	105	~~107~~	~~94~~	~~30~~	—
3	101	100	109	115	31	10 (1,3)
4	90	90	120	92	28	13,5 (1,8)
5	95	98	116	88	24	14 (1,9)
6	83	88	108	79	28	19 (2,5)
7	90	93	111	97	27	12 (1,6)
$M \pm m$	94,6±2,6	96,3±2,1	114±2,4	93,5±4	27,7±0,8	11,8±2,1 (1,83±0,15)

Key: TLC) total lung capacity; VC) vital capacity; mPAP) mean pulmonary artery pressure; RV) residual volume; FRC) functional residual capacity

Pressure in the pulmonary and radial arteries was measured using P-23Db sensors (Statham), which were placed on the level of the right atrium. Oxygen tension in arterial and mixed venous blood was measured by an electrochemical method (Clark electrode, AVL-940). Fluid content of the lungs, or lung tissue volume (LTV) was measured using a method, the theory and details of which have been described previously [3]. It consists in essence of inhaling a gas mixture containing 10% N_2O (a gas that dissolves well in liquids), 10% Ar (insoluble gas) and oxygen after a full expiration. The subject then holds his breath for 1-2 s and exhales slowly at a speeed ($\dot{V} = 0.2\ \ell \cdot s^{-1}$) that he controls himself by looking at a pointer-type dial. The velocity of gas flow ($\dot{V}$) and respiratory volumes (V) were measured with a pneumotachograph and heatable Fleisch No 1 head (Godart) connected to a mouthpiece through which the subject had to breathe. Partial gas tension in inhaled and exhaled air (pN_2, pO_2, pN_2O, pAr) was continuously measured with an RMS-BG (Godart) mass-spectrograph. The gas signal lag related to passage of the sample through the catheter constituted 360 ms and it was considered in the calculations. The tracings were made on a 6-channel Brush-260 recorder, while analysis of the curves and calculations were made on a PDP-8a computer using a specially developed ARGON program (which was developed by S. E. Kaminskiy).

During slow exhalation there is virtually no change in pAr in alveolar air, while p_aN_2O gradually drops, since N_2O is removed from the lungs and blood

at a velocity that is proportionate to pulmonary blood flow. When N_2O has not yet begun to pass from the alveolar space into the blood stream (t_0), the difference between N_2O and Ar pressures is a function of pulmonary fluid content [4], and it serves as the basis for calculating LTV. Functional residual capacity (FRC) and residual volume (RV) were determined from Ar dilution by the single expiration method.

The subjects were in horizontal position (background) after 30-40 min, 7 h, 3 and 7 days of continuous exposure to AOH at -15°. We took 3-5 measurements (each of which took 20 s) at each stage and calculated the means.

A PDP-8a computer was used for statistical processing by the methods of Student, Wilcoxson and correlation analysis.

Results and Discussion

In horizontal position, the subjects presented mean LTV of 557.0±19.0 mℓ (from 476 to 618 mℓ), FRC was 3.13±0.19 ℓ, while LTV/FRC ratio constituted 177.2±3.4 mℓ·ℓ$^{-1}$. Figure 1 illustrates graphically the dynamics of change in LTV during exposure to -15° AOH. As can be seen there, fluid content of the lungs 30-40 min after moving the subjects to AOH position increased in 4 subjects, decreased in 2 and did not change in 1 (P>0.05). By the 7th h of AOH at -15°, all subjects presented an increase in LTV by a mean of 10% (P<0.01), as compared to horizontal position, and it was associated with elevation of

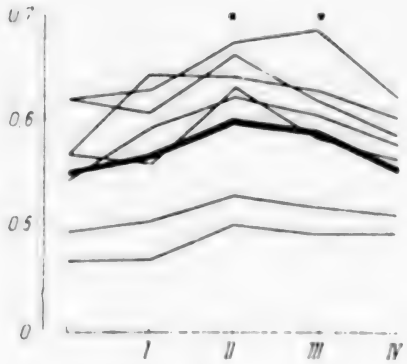

Figure 1.
Dynamics of LTV (ℓ) during 7-d AOH
Here and in Figure 2 x-axis refers to stages of study:
0) initial position (supine)
I) 30th-40th min of AOH
II) 7th h of AOH
III, IV) 3d and 7th days of AOH
Light lines show individual parameters for each subject; boldface line represents mean values
*P<0.05

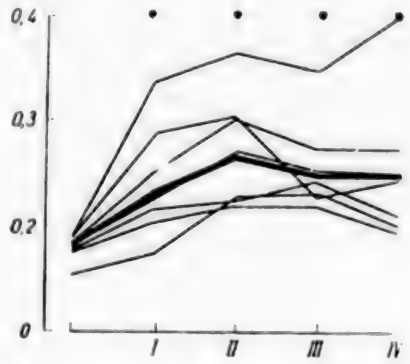

Figure 2.
Dynamics of normalized parameter of lung fluid content (LTV/FRC) during study

pulmonary artery pressure. Measurements on the 3d day revealed a tendency toward decline of LTV in comparison to the preceding reading in all subjects but one. However, mean LTV (593.0±60.5 mℓ) remained reliably (P<0.05) above the control level. On the last day of the study (7th day), the subjects with initially high LTV showed a significant decline, whereas in those with lower LTV

the level showed virtually no change from the value found on the 3d day. Mean LTV was close to the control level, 566.8±45.7 mℓ ($P>0.05$) by the 7th day of AOH.

The demonstrated values are consistent with data in the literature [9, 11, 15] and close to the mean LTV obtained for a more representative group of healthy subjects using the same equipment and method as in this study [3]. This warrants the belief that the methodological procedure we used is reliable and yields sufficiently accurate results. However, with reference to methods, it must be noted that the gas indicators introduced by inhalation reach only the ventilated parts of the lungs. N_2O and Ar do not reach regions of atelectosis and areas of large expiratory closure, consequently, the fluid in these regions cannot be "tagged" with the indicator and measured. Thus, when there is a reduction of effective alveolar volume the results of measuring LTV will be artificially underestimated. In order to make the results comparable with regard to measurements of LTV in individuals with different anthropometric parameters and altered pulmonary function, we expressed the fluid content of the lungs as the normalized parameter, LTV/FRC [3]. The base values for this parameter present less scatter than LTV (177.2±3.4 $m\ell \cdot \ell^{-1}$ and 557.0±19.0 mℓ, respectively). There is a tendency toward increase in LTV/FRC by the 3d day of AOH but, unlike LTV, this parameter does not revert to the base level on the 7th day of the study and remains reliably elevated, 252.3±24.8 $m\ell \cdot \ell^{-1}$ ($p<0.01$) (Figure 2), which actually reflects an increased amount of water in the lungs.

In one of the subjects (No 6), fluid content of the lungs appears abnormally high, as compared to the others: LTV/FRC increased by more than 2 times in that case. In the course of AOH, with normal base data, this subject also presented other deviations of pulmonary parameters from the values of the same parameters in the other subjects. For example, he presented the highest FRC and ERV [expiratory reserve volume] and, consequently, a ventilation level as well by the 7th h of AOH, which persisted to the end of the experiment. The LTV increase by the 7th h of AOH was also greatest in the group. In head-down tilt position, ERV exceeded FRC more in this same case than in other subjects. The change from horizontal to AOH position was associated with significant hyperventilation in the same subject ($PaCO_2$ = 29 mm Hg) with a greater respiratory volume (V = 1 ℓ), which persisted in the 7th h of AOH ($PaCO_2$ = 24 mm Hg) and was apparently aimed at opening the airways during inspiration. There are grounds to believe that the distinctive changes in gas exchange and lung volumes in this subject were due to more marked accumulation of fluid in pulmonary tissue during AOH.

Theoretically, the increase in LTV during AOH could be due to several causes: hyperdynamic circulation, elevation of filtration pressure in pulmonary microvessels, impairment of Starling's equilibrium, increase in permeability of pulmonary capillaries, poorer function of lymphatic system of the lungs, general hyperhydratation, plethora of pulmonary vessels. The increased passage of fluid from vessels into lung tissue, which is associated with temporary and entirely reversible interstitial pulmonary edema, is also possible even under physiological conditions as a result of increased cardiac output and pressure in the pulmonary artery, for example, during intensive physical exercise [8].

When subjects are changed to antiorthostatic position, elevation of pressure in pulmonary circulation vessels is observed, as with physical exercise, and there is a distinct correlation ($r \pm 0.58$; $P < 0.01$) between increase in LTV/FRC and increment of mean pressure in the pulmonary artery (mPAP).

During the first hours of AOH, which is associated with circulatory hyperdynamia, there is also increase in central blood volume, which includes intracapillary volume (Vc), equaling 60-90 mℓ.

Vc level is a rather rigid constant of the body, and it increases insignificantly or remains normal, even when there is marked pulmonary hypertension [7]. Consequently, the increase in LTV by the 7th h of AOH with concurrent elevation of end diastolic pressure of the pulmonary artery by 1-2 mm Hg is attributable expressly to accumulation of water in pulmonary interstices rather than accumulation of blood in pulmonary capillaries. This is confirmed by the experimental data of Gabel and Drake [6], who proved convincingly on the basis of gravimetric studies that the increase in lung mass is due to increased filtration and accumulation of fluid in tissue, rather than to increased vascular volume. Consequently, elevation of hydrostatic intravascular pressure in the absence of changes in other components of Starling's equilibrium (colloid-osmotic pressure of plasma and interstitial fluid, coefficients of permeability and reflection) leads to increased filtration through the capillary wall and accumulation of fluid in lung tissue. Under normal conditions, the walls of pulmonary capillaries allow aqueous solutions of low-molecular plasma substances to pass rather readily into the interstitial space of the lungs, from which excess fluid is usually removed through the lymphatic system. Under normal conditions, lymph flow in the lungs of an adult human constitutes about 10-20 mℓ/h and can increase in the presence of chronic pulmonary hypertension to provide a fluid balance in the lungs [14]. On the basis of our findings, it should be assumed that the increased fluid content of the lungs on the 3d and 7th days of AOH is probably due to impaired lymphatic drainage [18], change in colloid-osmotic pressure of interstitial pulmonary fluid [10] and increased permeability of the capillary wall. The influence of intravascular factors of transcapillary filtration of fluid in the lungs can apparently be ruled out, since the volume of circulating blood and pressure in vessels of the pulmonary circulatory system, as we know, diminish by the 3d-7th day of AOH [1, 13], while the concentration of protein and, consequently, osmotic-colloid pressure of plasma did not change in our subjects.

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MORPHOLOGICAL STUDY OF MYOCARDIUM OF MONKEYS SUBMITTED TO ANTIORTHOSTATIC HYPOKINESIA

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 6, Nov-Dec 84 (manuscript received 17 Jan 83) pp 44-48

[Article by A. S. Kaplanskiy, G. N. Durnova, Z. F. Savik, G. S. Belkaniya, V. I. Popov and D. S. Tavadyan]

[English abstract from source] By histological, morphometric and gravimetric methods the hearts of 7 monkeys exposed to head-down tilt at -6° were examined (2 monkeys were exposed to head-down tilt for 7 days and 5 monkeys were exposed to hypokinesia for 7 days and then to head-down tilt for 12 days; 4 additional monkeys were used as controls). During head-down tilt the heart weight increased due to blood pooling in the Thebesian vessels which was in turn associated with blood redistribution and accumulation in the vessels and parenchymal organs of the upper body. During 7- and 12-day head-down tilt myocardiocytes of the papillary muscles of the ventricles were not enlarged, and the number of functioning capillaries in the papillary muscles diminished.

[Text] At the present time it is a known fact that prolonged restriction of movement has an adverse effect on the human cardiovascular system and causes deconditioning of the myocardium [9, 14]. Investigation of functional and structural changes in the heart during hypokinesia with the head tilted down (AOH) is of special interest, since the latter is used extensively as a ground-based model simulating some effects of weightlessness [4, 5, 12, 19].

We submit here the results of a histological, gravimetric and morphometric investigation of the myocardium of monkeys submitted to AOH [antiorthostatic hypokinesia]. In setting up experiments on monkeys with AOH, it was assumed that the effect of redistribution of blood under AOH conditions would be more distinctly marked in animals spending a considerable time in erect position than in those in horizontal position. Moreover, the phylogenetic closeness of monkeys to man facilitates extrapolation of experimental data to him.

Methods

The hearts of 4 control and 7 experimental male Macaca mulata monkeys, which had spent 7 and 19 days under hypokinetic conditions combined with

antiorthostatic position of the body, served as the material of our investigation. Hypokinesia was produced by immobilizing the animals on special cots by a method developed at the Institute of Experimental Pathology and Therapy, USSR Academy of Medical Sciences [17]. In the experiments using hypokinesia for 19 days, the monkeys spent the first 7 experimental days under conditions of clinostatic hypokinesia and the next 12 days at -6° AOH. In the first experiment we used 2 experimental and 2 control monkeys weighing about 5 kg and in the second, 3 experimental and 2 control animals with a base weight of 3 to 4.3 kg. In addition, 2 monkeys weighing 3.3 kg initially used in the second experiment were submitted to AOH for 7 days without prior clinostatic hypokinesia. The control monkeys were kept in ordinary cages or pens throughout the experimental period. All of the monkeys were sacrificed by giving them intravenous injections of 2-3 mℓ 10% hexenal solution, which caused instant death.

Pathoanatomical dissection was started 10 min after death, evisceration of internal organs was preceded by ligation of great vessels, which prevented drainage of blood from large organ vessels and made it possible to determine more accurately the weight of the internal organs. After removal of fat and large vessels, the heart of each monkey was weight, with determination of absolute weight, weight of the left ventricle and interventricular septum, right ventricle and atria [6]. The cardiac index, ventricular index and Fulton's index were calculated on the basis of the obtained data [11]. Samples of the left and right ventricles, as well as the anterior papillary muscles of the right and left ventricles, were fixed in 10% neutral formalin and imbedded in "histoplast." Seria sections of the right and left ventricles, as well as papillary muscles cut perpendicularly to their long axis, were stained with hematoxylin and eosin, iron hematoxylin in a modification we proposed [7], picronigrosin according to (Friborn) and picrofuchsin. Sections of the ventricles cut on a freezing microtome were stained with Sudan black B for demonstration of lipids. We selected the anterior papillary muscles of the left and right ventricles for morphometric examination of myocardiocytes, since they are longitudinally oriented in these muscles. For determination of area of myocardiocyte cross section (ACS), transverse sections of papillary muscles stained with picronigrosin were photographed, and the negatives were projected on paper, then a pencil was used to outline 200 myocardiocytes taken from different parts of the section, cut out and weighed; the obtained figure was divided by 200, thus ultimately obtaining the mean ACS of a single myocardiocyte expressed in arbitrary units. To count the functional capillaries, we used cross sections of papillary muscles stained with iron hematoxylin. We used an ocular grid on an area of 1 μm^2 at 420× magnification for counting the capillaries. We calculated the radius of diffusion [16] in order to determine conditions of delivery of oxygen to tissues.

For stereological analysis of myocardiocyte mitochondria, samples of posterior papillary muscles of the left and right ventricles were fixed in 2.5% glutaric aldehyde and additionally in 1% osmic acid, dehydrated in alcohols of ascending strength and imbedded in araldite. Ultrafine sections were contrasted with lead citrate and uranyl acetate, after which they were examined under a JEM-100B electron microscope. Electronograms obtained at 10,000× magnification were used for stereological analysis of mitochondria, with use of a test grid with 5 mm spacing and during this analysis we determined the average number of mitochondria and their relative volume (in each case, we used 20 electronograms for stereological analysis).

Results and Discussion

Before we discuss the results of studying the myocardium of monkeys under AOH conditions, it must be noted that exposure of the animals to AOH led to considerable weight loss (Table 1) and was associated with redistribution of blood, with influx to the upper half of the body. Thus, upon dissection of experimental animals we were impressed by the plethora of vessels of the brain, meninges, soft tissues of the orbits, dilatation and plethora of deep and superficial veins of the neck and shoulder girdle, marked plethora of the lungs and liver. Plethora of the venous system of the upper half of the trunk, head, as well as lungs and liver of monkeys submitted to AOH is quite consistent with clinical and physiological findings [10, 12], to the effect that humans submitted to AOH also presented flow of blood to the head and upper half of the body.

Table 1. Changes in body and heart weight of monkeys submitted to AOH

Monkey No	Nature of experiment	Body wt., kg		Difference, %	Heart mass, g	Left ventr. weight, g	Rt. ventr. weight, g	Cardiac index	Ventric. index	Fulton's index
		before exper.	end of exper.							
	First experiment									
1	Control	—	5,150	—	18,240	7,350	3,370	3,54	0,46	3,85
2	"	—	5,130	—	17,800	7,390	3,650	3,47	0,49	3,41
3	7-d hypokinesia followed by 12-d AOH	—	5,100	—	20,650	8,850	3,950	4,05	0,45	3,56
4	Same	—	5,100	—	20,250	8,800	3,700	3,97	0,42	3,58
	Second experiment									
5	Control	3,000	3,200	7%	10,520	3,940	2,140	3,29	0,54	3,20
6	"	3,250	3,400	5%	10,760	4,220	2,170	3,16	0,51	3,24
7	7-d AOH	3,300	3,100	—6%	14,970	5,720	2,770	4,83	0,48	3,90
8	Same	3,300	3,300	—	14,100	5,700	2,620	4,27	0,46	3,62
9	7-d hypokinesia followed by 12-d AOH	4,450	3,500	—20%	16,600	6,450	2,900	4,74	0,45	4,00
10	Same	3,800	3,100	—18%	13,350	5,750	2,500	4,31	0,43	3,72
11	"	3,600	2,800	—20%	11,840	4,920	2,320	4,23	0,47	3,46

The results of gravimetric studies of the heart, which are listed in Table 1, indicate that monkeys submitted to AOH for 7 and 12 days presented absolute and relative (cardiac index) increase in heart mass, absolute increase in mass of left and, to a lesser extent, right ventricles of the heart. We also observed a decline of cardiac index (ratio of weight of right ventricle to weight of left ventricle) and increase of Fulton's index (ratio of weight of left ventricle and interventricular septum to weight of right ventricle), which was also indicative of predominant increase in mass of the left ventricle. The increase in weight of the myocardium in monkeys submitted to AOH could be due its hypertrophy or increased delivery of blood to the myocardium, or both at the same time. However, morphometric studies of papillary muscles of the left and right ventricles (Table 2) failed to demonstrate appreciable changes in myocardiocyte ACS in experimental monkeys, consequently the increase in

weight of the myocardium of animals submitted to AOH was unrelated to myocardial hypertrophy. The results of stereological analysis of mitochondria were also indicative of absence of hypertrophy of myocardiocytes of papillary muscles, since it demonstrated that there was no change in average number of mitochondria or in their relative volume in the posterior papillary muscles of the right and left ventricles of experimental monkeys (see Table 2; in the presence of myocardial hypertrophy, the first mentioned parameter usually increases while the second decreases) [15, 18].

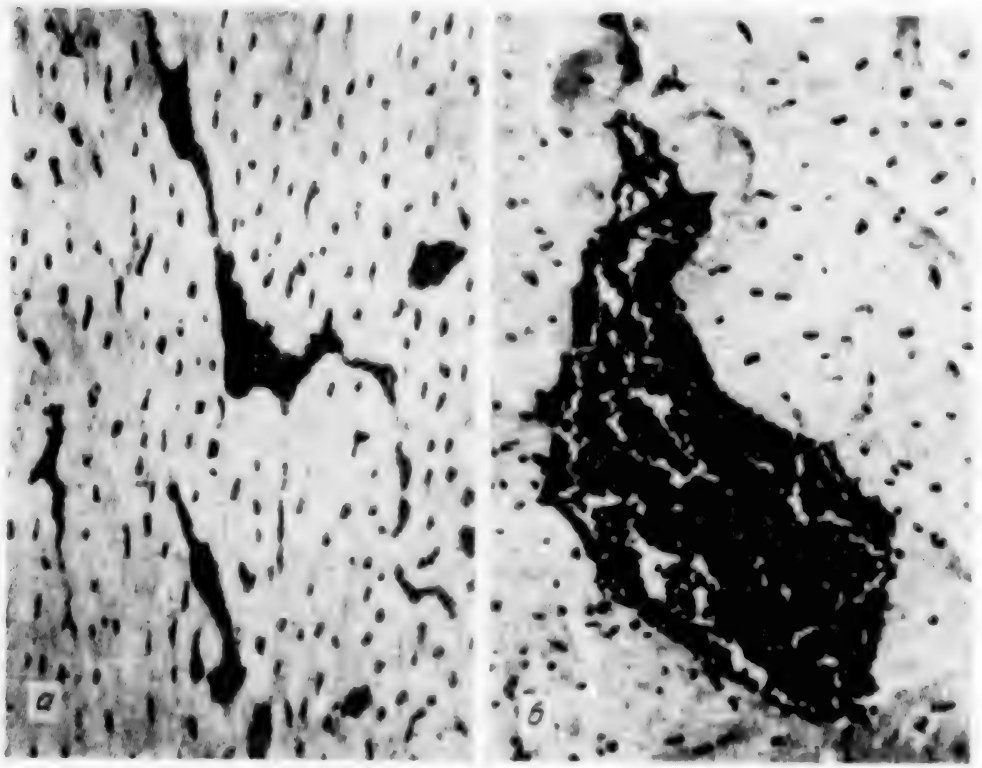
Table 2. Results of morphometric and stereological analysis of myocardial papillary muscles of monkeys submitted to AOH

Monkey No.	Nature of experiment	Mean myocardiocyte ACS, relat.units		Mean numb. of mitochondria		Relative mitochond. volume, %		Diffusion radius, μm	
		LPM	RPM	LPM	RPM	LPM	RPM	LPM	RPM
	First experiment								
1	Control	25,9	15,2	—	—	—	—	15	17
2	"	27,2	12,7	—	—	—	—	14	16
3	7-d hypokinesia followed by 12-day AOH	24,4	9,3	—	—	—	—	16	15
4	Same	20,5	15,9	—	—	—	—	15	15
	Second experiment								
5	Control	35,3	17,8	27	27	40	30	11	14
6	"	37,9	16,4	22	18	34	26	13	13
7	7-day AOH	38,8	18,4	20	25	33	32	12	14
8	Same	44,8	19,4	27	31	36	28	15	12
9	7-d hypokinesia followed by 12-day AOH	47,3	20,6	27	26	30	33	14	18
10	Same	36,2	15,6	—	29	—	31	14	16
11	"	36,9	18,4	28	27	25	41	13	15

Key: LPM and RPM) left and right papillary muscles, respectively

Quantitative study of the microcirculatory system of the myocardium revealed that there was some decrease in number of functional capillaries in papillary muscles of monkeys submitted to AOH, as a result of which the radius of diffusion increased (see Table 2). Most probably, the reduction in number of functional nutritive myocardial vessels was due to decreased load on the heart during AOH, and this had been repeatedly observed during clinostatic hypokinesia [1-3, 20, 21]. At the same time, histological examination of the myocardium of experimental monkeys revealed drastically dilated blood-filled sinusoid lacunae, which represented dilated segments of thebesian vessels (see Figure), in the subendocardial regions of the left and (to a lesser extent) right ventricles. Dilated thebesian vessels were encountered considerably less often in control monkeys, while the extent of vascular dilatation and plethora was never as great as in experimental animals. In view of the fact that the capacity of the vascular system formed by thebesian vessels is rather significant [13], it can be assumed that the increase in mass of the heart of monkeys submitted to AOH was related expressly to deposition of blood in thebesian vessels.

Predominant plethora of thebesian vessels of the left heart is attributable to the fact that with overfilling of the pulmonary circulation and right heart with blood, most myocardial venous blood is discharged through the system of thebesian vessels in the left heart chamber, whereas under normal conditions most venous blood of the myocardium passes through the coronary sinus into the chamber of the right atrium. A similar phenomenon occurs in human "cor pulmonale" [13]. In addition, the possibility cannot be ruled out that part of the blood is directed into the left heart through thebesian vessels, by-passing the pulmonary circulation, which reduces the load on the right heart and is instrumental in equalization of pressure in the chambers of the right and left heart [13].



Deposition of blood in myocardial thebesian vessels in monkeys submitted to AOH; iron hematoxylin stain; lens 3.5× and eyepiece 7×

a) thebesian vessel in left ventricular myocardium of control monkey
b) drastically dilated, blood-filled thebesian vessel in left ventricular myocardium of monkey submitted to head-down tilt at an angle of -6° for 7 days

Thus, under AOH conditions, in monkeys some blood is deposited in the system of thebesian vessels of the myocardium as a result of redistribution, with consequent increase in mass of the myocardium. It should be noted that increased blood in the myocardium is observed not only during AOH in monkeys, but clinostatic hypokinesia in rats [8], although it is apparently less

marked. In spite of plethora in the pulmonary circulatory system, we failed to demonstrate hypertrophy of the right ventricle with 7- and 12-day AOH. During AOH there was decrease in number of functional capillaries in the myocardium.

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FLUID METABOLISM OF MONKEYS DURING TWO-WEEK ANTIORTHOSTATIC HYPOKINESIA

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 6, Nov-Dec 84 (signed to press 31 Mar 83) pp 43-54

[Article by V. P. Krotov, Ye. G. Bazunova and B. S. Kulayev]

[English abstract from source] Water balance parameters were measured in hypokinetic rhesus monkeys using tritiated water. During exposure the water content decreased by 18.4%, with 11.3% lost within the first 7 days. The rate of water renovation measured with respect to H^3 half-life was decreased by a factor of 1.5 during the first week and increased by 10% during the second week, as compared to the pretest value. Daily water losses diminished by 30% during the first week and approached the pretest level during the second week. These findings are indicative of three phases in the time-course variations of water balance during head-down tilt.

[Text] The model of antiorthostatic [head-down tilt] hypokinesia (AOH) makes it possible to study quite accurately the different effects of weightlessness on the body. In particular, it was shown that the dynamics of change in human fluid content in weightlessness correspond to those under AOH conditions [4, 9].

Our objective here was to determine the effect of 14-day AOH (-6°) on dynamics of change in several parameters of fluid metabolism in monkeys.

Methods

Our investigation, which was conducted on 6 Macaca rhesus monkeys 3-4 years of age, included a background period (free upkeep in cages) of 7-10 days, period of AOH lasting 14-15 days and recovery period of 10-14 days.

The animals movements were restricted by a method developed at the Institute of Experimental Pathology and Therpay, USSR Academy of Medical Sciences. With this method, the monkeys' legs were immobilized with extended hip and knee joints. They retained freedom of movement at the elbow, wrist and ankle. The monkeys were in prone position throughout the AOH period. To assure antiorthostatic inclination, the foot end of the hypokinetic device was raised 11 cm from the table level (Figure 1). Considering that, in orbital flight,

early effects of weightlessness are manifested against the background of stress factors, we did not consider it expedient to precondition the monkeys for the hypokinetic device.

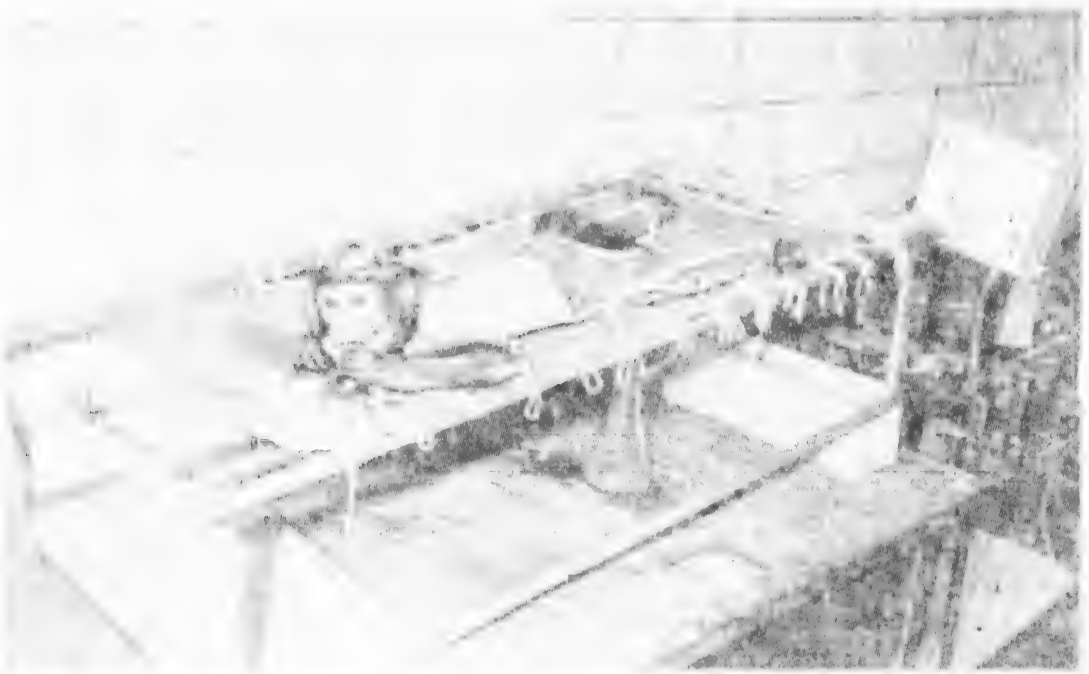

Figure 1. Macaca rhesus monkey immobilized on abdomen in antiorthostatic (-6° angle) position.

The diet was the same throughout the experimental periods. Water intake was not limited.

We used "tritium water" to examine parameters of fluid metabolism. This product, with activity of 10 μCi/kg body weight, was injected intramuscularly, and dosage was determined gravimetrically with a 1 mg margin of error. We determined body fluid content, mean daily fluid loss and rate of fluid replacement in accordance with the "Methodological Recommendations" [2]. Samples of blood plasma and 24-h urine served as material for analysis.

Specific resistance of plasma and urine was determined in a heat-controlled cell by the tetrapolar method, using an RPG-204 rheoplethysmograph.

The obtained data were submitted to processing by the method of variation statistics with determination of reliability of differences in results obtained on the same group [6].

Results and Discussion

When the animals were weighed 3-4 days before AOH, we found that they constituted a rather homogeneous group according to weight, with the exception of the one called Vanya (Table 1). Repeated weighing on the 10th day of AOH revealed that all monkeys had a weight loss averaging 15.3 ± 1.47% for the

group ($P<0.01$), the range of fluctuations being 8.8 to 35.6%. It should be noted that the width of the range was attributable mainly to the marked weight loss of Cheburashka. In the group of the other 5 monkeys, weight loss constituted 12.2±0.94% ($P<0.001$), ranging from 8.8 to 13.9%.

Table 1. Effect of AOH on dynamics of monkeys' weight changes

Animal's name	Period and days of weighing				
	backgr.	AOH		recovery	
	3-4	14		10-14	
	absolute, kg	absolute, kg	difference from background, %	absolute, kg	difference from background, %
Ryzhik	4.72	4.17	-11.7	4.50	-4.7
Gosha	5.10	4.65	-8.8	4.85	-4.9
Govorun	4.40	3.79	-13.9	4.05	-8.0
Toto	4.40	3.81	-13.4	3.90	-11.4
Vanya	7.62	6.60	-13.4	7.30	-4.2
Cheburashka	4.66	3.0	-35.6	4.20	-9.9

By the end of the 2d week of resuming motor activity not a single monkey regained its initial weight.

The distinctive reaction of Cheburashka to AOH was also referable to dynamics of change in studied parameters of fluid metabolism. For this reason, we deemed it expedient to analyze the data for this monkey separately.

Two-week AOH led to marked reduction of body fluid content. There was a more significant "discharge" of fluid during the 1st week of AOH. Thus, by the 7th day of AOH body fluid content decreased by a mean of 11.3% ($P<0.001$) with a range of fluctuations from 8.6 to 14.3% (Table 2). After 1 week there was an increase in fluid shortage, loss constituting 19.4% ($P<0.001$), as compared to base values. However, as compared to the 1st week of AOH, the rate of increase in dehydration decreased by almost one-third, to 8.1%. In Cheburashka, body fluid content decreased considerably more during AOH than in the other monkeys: by 21.4% by the 7th day and 35.6% by the 14th day, as compared to background value. At the same time, the changes in rate of build-up of the fluid shortage coincided with those in the group of monkeys: fluid loss was 34% greater in the 1st week of AOH than the 2d.

With resumption of motor activity there was increase in fluid content, and its level was only 3.4% lower than in the background period ($P<0.01$) after 10-14 days of unrestricted activity. This difference constituted 8.3% in Cheburashka.

Specific fluid content enables us to assess hydration of the body with consideration of change in body weight. In the background period, specific fluid content was 612±9.6 mℓ/kg body weight. After 2 weeks of AOH it decreased by 7.9% ($P<0.05$). It decreased by only 3.4% in Cheburashka (to 587 mℓ/kg versus 608 mℓ/kg in the background period). On the 10th-14th day of free activity, the amount of water per unit body weight not only exceeded the level during hypokinesia (by 11.6%) in all monkeys, but also its value in the

background period (by 3.7%; $P<0.02$); The figures for Cheburashka were 5.2 and 1.8%, respectively.

Thus, there was decline of both absolute and relative fluid content in all experimental animals during 2-week AOH at an angle of -6°. Sfter 10-14 days of unrestricted movement, fluid content was close to the base level, while its relative level even exceeded the background value.

Use of tritium water permits determination of rate of rehydration of the body, as can be judged by the tracer's half-life. In our studies, tritium water half-life in the background period constituted 6.0±0.30 days, ranging from 5.7 to 6.3 days. For the first 4-7 days of AOH, half-life increased to 8.5± 0.58 days (by 42%; $P<0.05$). However, during the second half of the AOH period there was a tendency toward normalization of fluid metabolism, and the fluid metabolic rate almost reached base value in two animals and even exceeded it in three. As a result, the half-life for fluid elimination was shorter for the group as a whole than in the background period--5.0±0.44 days (by 17%). During the first days of resumption of motor activity there was further acceleration of fluid metabolism, when its half-life decreased to 4.9±0.38 days (by 14%).

The kinetics of water metabolism during AOH underwent more marked change in Cheburashka: during the 1st week of AOH the rate of rehydration slowed down to almost one-third (isotope half-life increased to 14.5 days, versus 4.5 days in the background period); during the 2d week of hypokinesia, the rate of fluid metabolism increased, almost reaching the background level (half-life decreased to 5.2 days).

It is possible to calculate one more parameter, which characterizes the state of fluid metabolism, i.e., mean daily fluid loss, on the basis of amount of fluid in the body and rate of its replenishment. In the background period, this parameter ranged from 310 to 511 mℓ, constituting a mean of 384±44 mℓ/day for the group (Figure 2). In the first 4-7 days of AOH mean daily fluid loss decreased to 237±32 mℓ (by 38%; $P<0.02$). In the second half of the AOH period the level of fluid loss per 24-h rose to 361±31, remaining 6% lower than in the background period. With resumption of motor activity, mean daily fluid loss reached the background level, 391±28 mℓ.

A different pattern of mean daily fluid loss during AOH was demonstrable when we took changes in the monkeys' weight into consideration. In this case, it constituted 71±1.3 mℓ/kg per day in the background period. It increased by the end of the hypokinetic period to 82±10.9 mℓ/kg (by 16%, as compared to background) and even more on the first days of the recovery period, to 93± 10.8 mℓ/kg (by 31% as compared to background).

The most marked fluctuations of mean daily fluid loss during the experiment were found in Toto. Constituting 310 mℓ in the background period, fluid loss dropped to 250 mℓ (80.7% in relation to background) during the 1st 4 days of AOH, but then increased drastically, reaching 469 mℓ/day (151.3% in comparison to background) in the 2d week of AOH. With resumption of motor activity, mean daily fluid loss remained almost as high, 443 mℓ (142.9%, as compared to background).

Table 2. Dynamics of changes in parameters of fluid metabolism during experiment

Parameter	Statistical parameter	Period and day of examination			
		background	AOH		recovery
		3-4	7	14	10-14
TBF (total body fluid) absolute, mℓ	M	3196±335,7	2841±318,2	2593±312,0	3098±355,5
	$\pm m$				
	P	—	<0,1	<0,1	<0,1
difference from background, %	M	—	−11,28	−19,4	−3,4
	$\pm m$	—	1,26	2,41	0,85
	P	—	<0,001	<0,001	<0,01
Specific TBF absolute, mℓ/kg	M	612	—	564	633
	$\pm m$	9,6	—	22,0	17,4
	P	—	—	<0,1	<0,1
difference from background, %	M	—	—	−7,9	3,7
	$\pm m$	—	—	3,35	1,12
	P	—	—	<0,05	<0,02
ML (mean daily fluid loss) absolute, mℓ/day	M	384	237	361	391
	$\pm m$	44,3	32,0	31,1	28,4
	P	—	<0,05	<0,1	<0,1
difference from background, %	M	—	−35,12	−1,7	+22,9
	$\pm m$	—	7,15	16,86	20,0
	P	—	<0,02	<0,1	<0,1
Specific ML absolute, mℓ/kg•day	M	70,5	—	81,6	92,7
	$\pm m$	1,3	—	10,9	10,8
	P	—	—	<0,1	<0,1
difference from background, %	M	—	—	+16,0	±35,6
	$\pm m$	—	—	19,02	27,35
	P	—	—	<0,1	<0,1

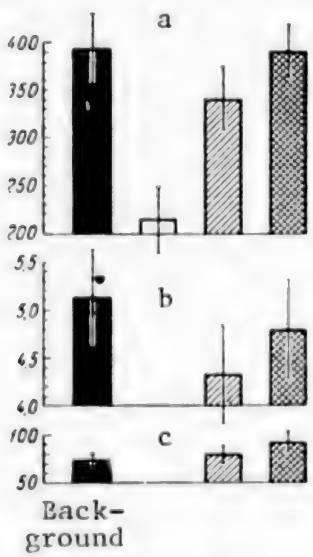

Figure 2.
Dynamics of change in mean daily fluid loss during AOH
a) mean daily fluid loss (mℓ/day)
b) body weight (kg)
c) specific mean daily fluid loss (mℓ/kg/day)

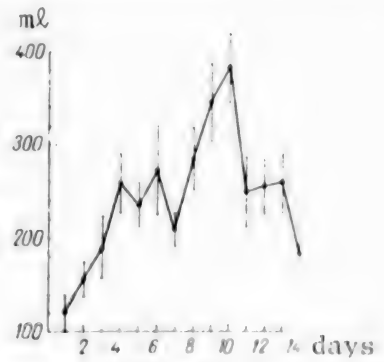

Figure 3.
Effect of AOH on dynamics of monkeys' diuresis
X-axis, duration of AOH (days);
y-axis, diuresis (mℓ)
Black bars--background; white--7th day of AOH; striped--14th day of AOH: cross-hatched--10th-14th day of recovery period

During AOH, there was decline of both absolute amount of fluid eliminated per day and in level scaled to the unit of body weight in Cheburashka.

During the experiment, diuresis of the monkeys presented marked individual differences. The data in Figure 3 illustrate the distinctive dynamics of diuresis: drastic decline on the 1st 2 days, a plateau on the 4th day of AOH (about 250 mℓ), 1.5-fold increase on the 9th-10th day and then 250 mℓ, which corresponded to the background value.

We demonstrated distinct changes in total electrolyte concentration in plasma during the experiment. In the background period, specific plasma resistance constituted 64.8±1.31 Ω/cm. On the 7th day of AOH it rose to 70.8±1.79 Ω/cm ($P<0.02$). By the end of the experimental period, specific resistance of plasma demonstrated a tendency toward decline, but remained above the background level, 68.8±1.25 Ω/cm ($P<0.05$).

In addition to changes in blood plasma electrolytes, AOH led to change in correlation between the plasma and globular components in the blood stream. Thus, while hematocrit constituted 43±1.6% in the background period, it was 48±1.8% ($P<0.05$) on the 7th day of AOH in 5 out of 6 monkeys. As compared to the 7th day, the changes were in different directions on the 14th day of AOH: hematocrit dropped in 3 monkeys, rose insignificantly in 1 and did not change in 2 animals; on the whole for the group, hematocrit constituted 45±1.6%. On the 10th-14th day of free activity, hematocrit remained on the background level only in Ryzhik, whereas in the other monkeys it was somewhat below the background value, 37±1.7% ($P<0.05$).

The results of our studies revealed that, in monkeys submitted to 2-week AOH, there is a decrease in fluid content, and it is more marked in the 1st week of the experiment.

Experiments conducted on animals differing in initial level of motor activity (dogs, rabbits, rats) revealed that, in the case of horizontal orientation of the long axis of the body when there is no shift of body fluids, fluid content does not change for the first 2-3 weeks of restricted movement [3]. Furthermore, during the first 2-3 weeks of hypokinesia the amount of fluid even increases due to a reaction to the changed situation. It is known that emotional stress increases ADH secretion [8]; as a result there is increased reabsorption of osmotically free water and decrease in diuresis. Expressly a stress reaction can explain the decreased diuresis in the monkeys during the first 2-3 days of AOH.

Consequently, the significant decrease in body fluids found in the monkeys during AOH was related to change in position of their body in relation to the vector of earth's gravity. In this case, regulation of redistributed body fluids is effected mainly by neuroendocrine mechanisms, which influence the nature of elimination of fluid and salts from the body [1]. Analogous changes in fluid metabolism arise in people on bedrest in antiorthostatic position. The rate of decrease in body fluids may be at a maximum for the first few days of AOH [4].

Thus, dependence of fluid metabolism on position of the body in relation to the horizontal plane is inherent in both animals and man.

The rate of rehydration, as determined by the half-life for elimination of tritium water, slowed down by more than 1.5 times during the 1st week of AOH and exceeded the background level by 10% during the 2d week. The rate of rehydration is determined by two factors: fluid intake and mean daily fluid loss. Although we did not measure the monkeys' fluid intake during AOH (because it was impossible to measure it precisely in succulent feed), from the daily entries in the log it is apparent that the monkeys, while they had a good appetite, consumed appreciably less water for the first 2-4 days of AOH. Thereafter, water intake increased. Only Gosha and, particularly, Cheburashka either refused water throughout the period or drank it quite unwillingly. An analogous decline of fluid intake was observed in humans during bedrest [7].

Analysis of the dynamics of total fluid loss during the 1st week of AOH (decline to 2/3, as compared to the background) enables us to conclude that fluid metabolism changes to a significantly narrower balance level in monkeys during this period. These changes in fluid metabolism were the most vivid in Cheburashka.

Water balance was different during the 2d week of AOH: there was increase in rehydration rate (half-life for elimination of isotope 10% shorter than the background level), while mean daily fluid loss was close to background values. If, however, fluid loss is evaluated with consideration of changes in body weight, it even exceeded background values by 8% during this period. Most likely, these changes in fluid metabolism were attributable to metabolic changes with prevalence of catabolic over anabolic processes. The reduction of fluid content observed in the monkeys was due to the fact that the animals lost 8-14% of their weight during AOH, and Cheburashka lost 36% of her background weight.

Thus, we can single out three phases in the dynamics of changes in monkeys during 2-week AOH at an angle of -6°: first phase (first 2 days of AOH) is characterized by drastic decline of fluid intake and elimination, which is the result of acute stress; in the second phase (3d-7th day of AOH), against the background of decreased fluid intake, there is increase in renal loss that leads to reduction of body fluids. Such a decline of body fluids does not occur during hypokinesia in animals differing in inherent motor activity (dogs, rabbits, rats), provided the long axis of their body is kept horizontal. Consequently, the "discharge" of fluid observed in the monkeys during this period is due to the position of the body's longitudinal axis at a -6° angle, in relation to the horizontal plane, and related shifting of body fluids in a cranial direction. In the third phase (8th-14th days of AOH), body fluid content continues to diminish, though at a slower rate. This occurs against the background of increased fluid intake and mean daily fluid loss; the rate of fluid metabolism increases. In this case, the observed changes in fluid balance are apparently attributable to impairment of other types of metabolism, in particular that of protein and fat, which leads to additional elimination of fluid from the body.

Our findings indicate that, in spite of the stressful situation, the monkeys retained the general patterns of change in fluid metabolism attributable to two factors: restricted mobility and antiorthostatic position of the body.

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DISTINCTIVE MORPHOLOGICAL MANIFESTATIONS OF ACUTE STRESS REACTION IN ADRENAL CORTEX OF HYPOKINETIC RATS

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 6, Nov-Dec 84 (signed to press 17 Jan 84) pp 54-58

[Article by Ye. V. Vorotnikov]

[English abstract from source] Adrenal changes in response to an acute stress-effect (5-h immobilization stress) were investigated in female rats exposed to hypokinesia for 3 months. The rate of delipoidization in the adrenal cortex increased in the rats exposed to an acute stress after short-term (1-2 weeks) hypokinesia. The process of delipoidization did not advance in the rats exposed to an acute stress in the course of prolonged (2-3 months) hypokinesia. This does not yet prove the lack of the stress reaction but gives evidence that during prolonged hypokinesia the adrenals develop the capacity to react to an additional effect without the entire complex of morphological signs typical of an acute stress reaction. The immobilization test used to assess the state of the adrenal cortex has shown that it does not deteriorate even during 3-month hypokinesia (in this study).

[Text] At the present time, many researchers believe that animal adaptation to chronic stress leads to a change in their reaction to an acute stress factor [7, 12, 15-17].

Our objective here was to investigate reactivity of the adrenals during hypokinesia, which is associated with chronic stress [2, 4]. We used an additional acute factor, in the form of immobilization stress at different stages of hypokinesia, in order to assess the functional capacities of the adrenal cortex.

Methods

Adrenals of 250 mongrel female rats, with a base weight of about 170 g, served as the material for our study. Experiments were conducted with the following groups of animals: first group consisting of vivarium control animals; second group, intact rats submitted to acute stress; third, animals submitted to hypokinesia for 3 months; fourth, rats submitted to acute stress against the background of hypokinesia.

To produce hypokinetic conditions, the animals were placed in individual box-cages that restricted their movements significantly. Acute stres was produced by immobilizing the rats for 5 h in an extended prone position on special tables [4].

The adrenals were collected on the day when the experiments were started (basic control), after 1 and 2 weeks, 1, 2 and 3 months of hypokinesia, as well as 1 month after its termination. At these times, we decapitated 8-10 rats from each group and determined their body and adrenal weight. One adrenal was fixed in 10% neutral formalin and imbedded in histoplast; the other was frozen in dry ice. Adrenal sections imbedded in histoplast, 4-5 μm in thickness, were stained with hematoxylin-eosin and "astrin." The latter technique permits differentiation between active and inactive cells according to differences in coloration of their nuclei: in active cells, nuclei with chromatin in a dispersed state are stained blue by astrin, whereas in inactive cells nuclei containing condensed chromatin are stained red by astrin [13]. Adrenal sections (10 μm thick) prepared in a cryostat were used for demonstration of lipids, staining them with Sudan black B and oil red O.

For quantitative evaluation of changes in functional activity of adrenocortical cells, we counted 300-500 nuclei in the top layer of the fascicular zone on astrin-stained sections and determined the proportion of active and inactive cells.

The digital data were submitted to statistical processing according to Student, considering differences between compared parameters to be reliable at $P<0.05$.

Results and Discussion

It should be noted, first of all, that the rats were in satisfactory condition throughout the experiment and there were no deaths. The weight of rats kept under hypokinetic conditions was significantly lower than in the control group but did not differ from the weight of rats in the "basic control." After hypokinesia, weight began to increase rapidly and was close to that of control animals after 1 month without actually reaching the latter. Acute 5-h stress caused 10-15 g weight loss in control and experimental rats.

Examination of the adrenals revealed that their absolute mass increased in the first 60 experimental days in control animals. Thereafter, adrenal growth stopped and absolute weight remained constant. The relative mass of the adrenals of control rats decreased with advance in age for the first 2 months of the experiment, after which it became stabilized and unchanged to the end of the study.

Absolute weight of the adrenals of hypokinetic rats, with the exception of animals decapitated 7 days after the start of the experiment, was lower, while relative mass was higher than in control animals (Figure 1). Acute 5-h stress did not elicit changes in adrenal weight of either experimental or control rats at all stages of the experiment. As shown in our preceding studies, changes in adrenal weight are observed with this form of stress only 24 h after the start of its effect [1].

Figure 1.
Dynamics of change in relative weight of female rate adrenals during 90-day hypokinesia and after it

X-axis, duration of hypokinesia (days); y-axis, relative mass of adrenals (mg/g). On all days but the 7th, there were statistically reliable difference between control and experiment (P 0.05)

I) hypokinesia
II) recovery period
1) rats submitted to hypokinesia
2) control animals

Histological examination of the adrenals of hypokinetic rats revealed a set of changes typical of "progressive transformation" of their cortical substance, analogous to the findings reported in [7, 8]. There was hypertrophy and thickening of the fascicular zone due to thinning of the glomerular and reticular ones. The fascicular zone remained widened to the end of hypokinesia. In the adrenals of control rats decapited immediately after 5-h exposure to stress, we demonstrated early signs of "progressive transformation" of the cortical substance, in the form of vague interzonal boundaries and enlargement of cell nuclei in the fascicular zone of the cortex. When the animals were immobilized at different stages of hypokinesia, cortical architectonics did not change, as compared to the initial background ("pure hypokinesia"). We were only able to observe considerably greater vascular plethora.

Investigation of lipid content of the adrenals revealed that total amount and distribution of lipids in the cortical substance of control rats did not change throughout the experiment. Lipid droplets were demonstrable in all cortical zones (with the exception of the subglomerular layer). The "density" of their distribution decreased toward the medullary substance, so that they were usually not demonstrable in the internal parts of the reticular zone. After 1 week of hypokinesia, all of the reticular and lower third of the fascicular zone were wanting in lipids, while small droplets of lipid appeared in the glomerular zone. Lipopenia of the cortex diminished with 2-week hypokinesia; on the 30th day there was considerable accumulation of lipids through the cortex. The fat drops were very large in cells of the glomerular and upper third of the fascicular zone. After 2 and 3 months of hypokinesia, as well as 1 month after its termination, lipid content of the cortex was the same as in control animals, but the sudanophobic layer was not restored. Control rats submitted to the acute stressor presented marked lipopenia of the cortical substance (Figure 2a), which extended in some areas to the external segments of the fascicular zone. In spite of the fact that the intensity of lipid depletion diminished somewhat with increase in age of the animals, the reticular zone and half the fascicular one were always wanting in lipids. In rats submitted to hypokinesia for 7, 14 and 30 days, acute stress also elicited lipopenia of the cortical substance but it was much less marked than in control animals (Figure 2b). When hypokinesia was extended to 2 and 3 months, the acute stress factor did not cause change in adrenocortical lipid content. The reaction of the adrenals of experimental and control rats to 5-h immobilization was the same 1 month after hypokinesia, and lipopenia involved the reticular and lower half of the fascicular zone.

Figure 2. Lipopenia of [illegible] after cold immobilization [illegible]; Lange 3.5, eyepiece 10
a) delipoidization in adrenal [illegible]
b) less delipoidization in adrenal [illegible] subjected to hypokinesia for 14 days

Dynamics of change in percentage [illegible] of proportion of active cells in top layer of [illegible] cells in the ocular zone of rat adrenal [illegible] 30-day hypokinesia and af[illegible]

	Day of hypokinesia			
	7	14	30	60
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	94 ± 2	67 ± 1	62 ± 2	69 ± 2
[illegible]	[illegible]	66 ± 2	75 ± 4	[illegible]
[illegible]	[illegible]	64 ± 1	65 ± 4	[illegible]

*Statistically reliable differences between control and experimental animals ($P<0.05$).

[illegible] zone of the cortex [illegible]. Lipopenia of the interrenal

in number of active cells in the adrenal cortex, which were observed in the rat for the first 2 weeks of hypokinesia, are typical of the anxiety stage of the general adaptation syndrome. Accumulation of lipids in the adrenal cortex on the 30th day of hypokinesia was indicative of replacement of the anxiety phase with the stage of resistance of the general adaptation syndrome, which lasted to the end of the hypokinetic period. At the resistance stage, adrenal hypertrophy persisted, while lipid content of the cortical substance gradually reverted to normal, virtually failing to differ from the control on the 60th and 90th days of hypokinesia. There were no morphological signs of depletion of the adrenals in our experiment, which is in contradiction to the findings of some authors [3] and apparently is attributable to the less rigorous hypokinetic conditions for the rats in our experiment.

Comparative evaluation of the adrenal reaction to immobilization revealed that the morphological manifestations of acute stress reaction in the cortex at all stages of hypokinesia were less marked in experimental animals than control rats submitted to the same factor. While we still observed partial delipoidization of the fascicular zone of the cortex at the early stages of hypokinesia after the additional stress of immobilization, at later stages of the experiment no distinct signs of lipopenia were demonstrable. Our data are in good agreement with the results of morphological and biochemical studies [15, 16], which demonstrated that cortical delipoidization in response to additional acute stress, in the case of prolonged stress factors, depends largely on duration of prior chronic stress.

The absence of marked lipopenia of the adrenal cortex of rats submitted to hypokinesia in response to an acute stress factor is apparently attributable to an increase in functional capacities of the cortex in the course of animal adaptation to hypokinesia; for this reason, more intensive corticosteroid production by the adrenals in response to the additional extreme factor was not associated with substantial morphohistochemical changes in the gland's tissue. Indeed, while we observed not only hypertrophy of cells in the fascicular zone of the adrenal cortex during adaptation to chronic hypokinetic stress, but increase in number of corticosteroid-producing cells (as a result of transformation of part of the cells of the reticular zone and cells of the subglomerular layer into fascicular cells), the substantial increase in hormone production by the adrenals in response to a stressor could occur without marked delipoidization of fascicular zone cells. In other words, as believed by Ye. A. Savina [7], the structural change in the adrenals, which occurs during adaptation to hypokinesia on the cellular and organic levels, is the basis for considerable increase in functional reserve of the adrenals. In addition, we cannot rule out the possibility that the acute stress factor elicits rapid dissociation of protein-steroid complexes of blood plasma in hypokinetic rats which, in turn, leads to release of active, free corticosterone [11] and is instrumental in raising the latter's level in blood and tissues.

We already mentioned that the number of actively functional cells remained at the same level in the adrenal cortex of rats, with both acute stress factors and long-term hypokinesia, and this level was higher than in control animals. This is apparently due to the fact that the factors used were strong enough to trigger a response by the entire reserve of inactive cells, with the exception

of only the pool required to compensate for the natural loss of cells that cease to function and to maintain the organ's work capacity for a long time. It should be assumed that involvement in the reaction of all fascicular cells (this could occur with even stronger stress factors) would lead to development in the adrenals of the set of pathological changes typical of the depletion stage of the general adaptation syndrome.

Thus, the results of this study indicate that, in the case of prolonged hypokinesia, the hypertrophied adrenals acquire the capacity to react to additional factors without development of the entire set of morphological signs inherent in the acute stress reaction. In stressed animals submitted to long-term hypokinesia, there is no development of lipopenia in the adrenal cortex; however, this is not proof of absence of a stress reaction. Use of immobilization stress as a test to assess the functional state of the adrenal cortex convinced us that 3-month hypokinesia (under our experimental conditions) does not lead to depletion of adrenocortical function.

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PREVENTIVE EFFECT OF ACUTE HEAT FACTORS DURING HYPOKINESIA

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 6, Nov-Dec 84 (manuscript received 15 Jun 83) pp 58-62

[Article by V. I. Sobolevskiy and V. P. Pravosudov]

[English abstract from source] Rat experiments have shown that adaptation to acute thermal effects increases the functional ability of the heart and blood circulation. This results in an increased thermal tolerance and hypoxic resistance of the myocardium. The prophylactic effect of acute thermal exposures during hypokinesia is related to a significant reduction of the level of metabolic and functional changes in the heart and skeletal muscles during diminished motor activity.

[Text] At the present time there are specific data on the preventive and protective role of a number of factors (hypoxia, physical exercise, etc.) when man and animals are submitted to hypokinesia [2, 10]. The effect of acute thermal factors on the body's functional state when motor activity is restricted requires in-depth experimental analysis because of the data in the literature concerning the conditioning effect of exogenous hyperthermia on physiological systems [5, 14]. This is the topic of our report.

Methods

Experiments were conducted on white mongrel male rats weighing about 200 g, which were kept on a standard diet. For the studies, we formed 3 groups: the first consisted of 30 animals, which served as a control; the second, 43 rats submitted to acute heat (AH) twice a day for 20 min at a time (with 30-min rest) in a TVZ-25 heat-controlled chamber with spontaneous ventilation at a temperature of 45[illegible].5°C and relative humidity of 15-20%; the third group of animals was submitted to hypokinesia for 30 days, as produced by using individual box-cages the dimensions of which enabled the animals to move only the head and forelegs in order to eat. After 20 days, we studied the dynamics of parameters of functional state during adaptation to AH in part of the rats in the second group (24 animals, subgroup 2a). The remaining 19 animals in this group (subgroup 2b) were submitted to hypokinesia for 30 days, continuing exposure to heat by the method described. Other than the periods of exposure to AH, intact and experimental animals were kept under vivarium conditions at a temperature of 20-22°C.

We monitored rectal (T_r) and skin (T_s) temperature of all animals. We recorded, under urethane anesthesia (160 mg/kg), the EKG in standard and chest leads. Upon termination of the experiments, we analyzed blood for assay of erythrocytes and hemoglobin, tested osmotic resistance of red cells in 0.5% sodium chloride [2]. After decapitation, we prepared cryostat sections of the myocardium and femoral muscle (m. biceps femoris) for histochemical determination of succinate dehydrogenase (SDH) activity by the method of Nachlas et al., with inhibition by sodium malonate of different concentrations in the reaction medium; phosphorylase and branching enzyme activity was determined according to Takeushi, uridine diphosphoglycogen transferase (UDPGT) activity was measured according to Takeushi and Gliner, lactate dehydrogenase (LDH) activity, by the method of Hess et al. Glycogen content was determined by the conventional method [7].

Results and Discussion

Animal adaptation to AH led to attenuation of behavioral heat-regulating reactions by the end of the experiment during exposure to heat and to 0.13±0.05 and 0.15±0.03°C less increment of T_r and T_s, respectively ($P<0.05$), as well as reliable increase in hemoglobin content and red cell count, which was indicative of increased oxygen capacity (see Table) and osmotic resistance of red blood cells ($P<0.05$), which plays an important part in mechanisms of heat adaptation [3]. There was no reliable change in weight of the heart.

Changes in parameters of functional state of animals in different experimental groups (M±m)

Parameter	Base data	Group 2a n=24	Control n=10	Gr.2b n=19	Contr. n=10	Gr. 3 n=18	Control n=0[illegible]
Animals' weight, g	196±8,8	240±9,6	237±7,8	241±5,7*	269±9,2	172±4,5*	236±[illegible]
Wet heart wt., mg	544±10,9	698±28	671±30,5	746±12	744±26	672±19	690±[illegible]
Red cells, millions	5,6±0,11	8,3±0,2*	5,8±0,1	5,9±0,1	6,1±0,2	4,5±0,5*	6,1±0,1
Hemoglobin, g%	13,9±1,2	17,4±1,2*	13,9±0,9	12,9±1,2	14,1±1,2	7,9±0,8*	13,4±0,6
Osmotic resistance of erythrocytes--hemolyzed erythr. as % of total count	32,5±2,7	23±1,4*	34,5±2,0	32±2,0	35,6±3,5	43,2±3,0*	1,1±0,3
Myocardial hemoglobin content, mg%	418±22,0	415±19,1	408±23,1	396±16,8	410±14,0	184±9,6*	11±16,6

*P<0,05, as compared to the control.

Histochemical analysis of energy metabolism in the myocardium during the first 20 min of heat exposure revealed, in both AH-adapted and intact rats, intensification of SDH activity, as manifested by disappearance of nonuniform distribution of reaction products and formation of linear diformasan deposits. There

was no reliable change in glycogen content, while activity of the other enzymes tested did not differ from background values. The second 20-min heat exposure elicited in both groups of animals a decline of total dehydrogenase activity in the myocardium and femoral muscle (replacement of linear form of diformasan with granular), intensification of phosphorylase activity, which was indicative of focal intensification of glycogen utilization, since the demonstrated enzyme participates in the first stage of anaerobic conversion of carbohydrates during glycogenolysis. There was a decrease in glycogen content; activity of branching enzyme and UDPGT did not change. It is known that the increase in blood catecholamine and corticosteroid content, which is observed with hyperthermia [5, 6, 8], increases myocardial oxygen requirement and, against the background of overheating of the body and increased functional activity of the myocardium, this causes a state of relative hypoxia [12, 13] and leads to attenuation of aerobic metabolism, as well as compensatory activation of glycolysis [6].

It is important that, with increase in overheating time to 40 min, AH-adapted animals showed a less marked decrease in total dehydrogenase activity than the control group; this was not associated with formation of granular formasan, which was indicative of decline of physiological mitochondrial functions and activity of redox enzymes located in the mitochondria [1, 9], as well as better ECG--signs of impairment of repolarization phase (decline of S-T segment and negative T wave) noted in the group of intact animals. The latter is apparently due to local energy deficiency as a result of diminished mitochondrial function and focal metabolic impairment, which cause an electrolyte imbalance [1, 9] and electrophysiological disturbances. In AH-adapted rats, glycogen content of the myocardium and skeletal muscle was reliably higher, which is attributable to more intensive activation of branching enzymes and UDPGT than in the control group. However, LDH activity in both the myocardium and femoral muscle did not differ from the control, indicating mild aerobic oxidation of blood lactic acid.

Thus, considering the positive dynamics of oxygen capacity with adaptation to AH, it can be assumed that moderate, intermittent hyperthermia improves functional capacities of the myocardium and resistance of the myocardium to deleterious factors, in particular, hypoxia.

The data listed in the table are indicative of the beneficial effect of AH on hypokinetic rat reactions. Thus, upon termination of the experiments, the animals in the 3d group weighed 23.8% less than control animals, whereas those in subgroup 2b weighed only 14.1% less. It is known that hypokinesia reduces oxygen capacity [2, 10]. In our experiments, AH had a normalizing effect on the blood system under hypokinetic conditions: hemoglobin and erythrocyte content held at a rather high level in rats of subgroup 2b and was reliably higher than in animals of the 3d group.

Histochemical analysis of energy metabolism in the myocardium and femoral muscle of rats in the 3d group revealed attenuation of aerobic metabolism (decrease in SDH activity), diminished activity of phosphorylase and LDH, particularly in the skeletal muscle, as well as reliable decline of myocardial glycogen, as compared to animals in 2b and control groups. The ECG of animals in the 3d group showed signs of impaired repolarization (decline of S-T segment and T wave) in the chest leads, which were not present in rats of subgroup 2b. Such

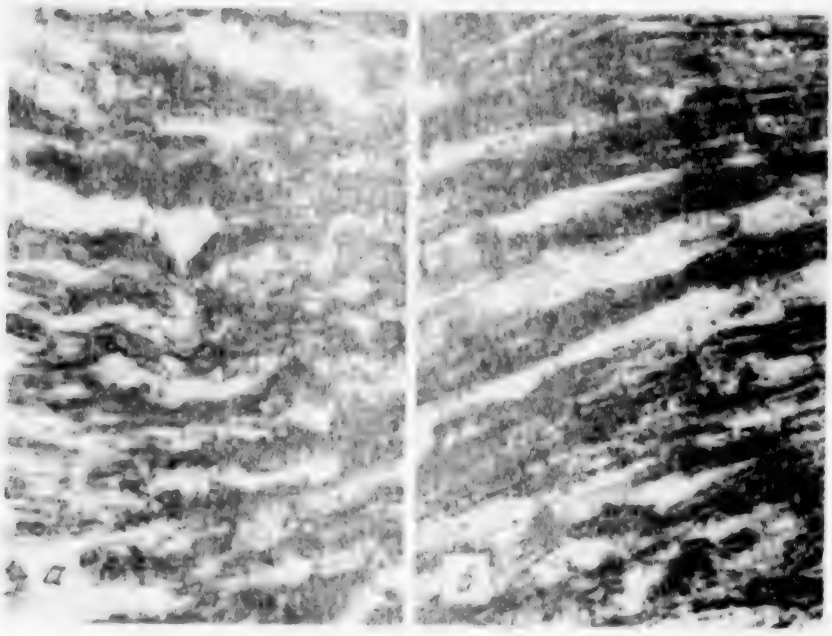

Figure 1. LDH activity in rat myocardium; Hess et al. reaction; magnification 350×

Here and in Figure 2: a) hypokinesia (3d group)
b) hypokinesia plus acute heat (subgroup 2b)

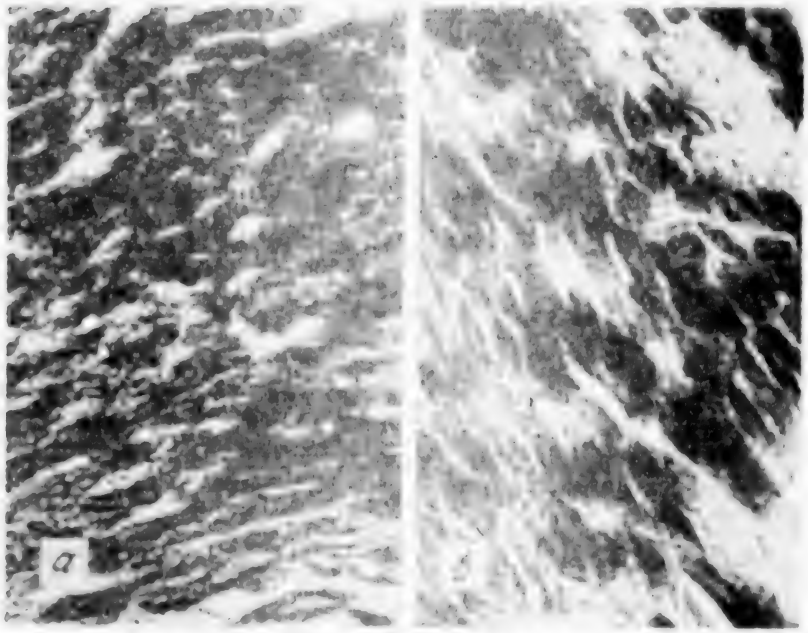

Figure 2. Branching enzyme activity in rat myocardium; Takeushi reaction; magnification 350×

changes had also been noted by other authors under hypokinetic conditions [4, 10, 11]. However, preadaptation to AH and exposure to it during restricted mobility of animals led to less marked metabolic changes in the myocardium and skeletal muscle of the thigh. In subgroup 2b rats, there was less depression of aerobic processes, in particular, SDH activity, and less decline of LDH activity (Figure 1), with normalization of glycogen content due to greater intensification of branching enzyme (Figure 2) and UDPGT activity. The animals presented no disturbances of cardiac bioelectrical activity, while red blood cell count and hemoglobin were reliably higher than in the third group of animals.

Thus, the results of these studies enable us to conclude that wise use of acute heat is instrumental in augmenting the physiological capabilities of the animals' myocardium and blood system, which is manifested by increase in heat tolerance and myocardial resistance to hypoxia. The preventive result of preadaptation to acute heat and the protective role of brief use of heat during the hypokinetic period are manifested by substantial attenuation of metabolic and functional changes in the myocardium and skeletal muscles of the thigh, as well as reliable improvement of oxygen capacity.

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INVESTIGATION OF ADAPTIVE DISTINCTIONS OF MECHANISM OF CONTROLLING GLYCEMIA IN MACACA RHESUS MONKEYS

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 6, Nov-Dec 84 (manuscript received 4 Apr 83) pp 62-66

[Article by G. S. Belkaniya]

[English abstract from source] Reactions of adult rhesus monkeys to the glucose tolerance test and the insulin sensitivity test were examined during different exposures. It was found that both tests can be well used to evaluate responses to various environmental effects, psychoemotional strain, acute stress state and orthostatic effects. Orthostatics was shown to potentiate the inhibition of insulin secretion. The reciprocal relationship between glucose tolerance and insulin sensitivity was detected in the functional range of vago-insular regulation. The role of orthostatics in neurogenic disorders of the mechanism of glycemic regulation is discussed. The synergism of the combined effect of orthostatics and psychoemotional strain is described.

[Text] The neuroendocrine complex for controlling glycemia [3, 9] is one of the most important systems of the body, that implement and reflect its adaptability when exposed to diverse environmental factors. In this regard, it can be assumed that the systems of regulating glycemia are highly sensitive to neurogenic factors. This is validated by data to the effect that stress situations, physical strain and mental trauma rather often become the prime risk factors in development of diabetic states [4, 5].

In turn, the polyneuropathic and angiopathic disorders, which develop with diabetes, lower significantly the body's resistance to physical and mental stress, and they are one of the causes of death associated with diabetes [5]. This indicates that the state of the neuroendocrine complex of regulating glycemia is one of the important elements providing for nonspecific resistance and reactivity of the body.

In view of the foregoing, our objective here was to investigate the adaptive capacities of mechanisms of controlling glycemia in monkeys as related to different functional factors. Such formulation of studies is expedient in connection with a search for the most informative tests and functional tests that permit evaluation of the functional capacities of monkeys being prepared for biological experiments aboard artificial earth satellites.

Method

The studies were conducted on sexually mature male Macaca rhesus monkeys 4-5 years of age, kept at the Sukhumi Primate Vivarium. We performed the intravenous glucose tolerance (GTT) and insulin sensitivity (IST) tests under the following experimental conditions: on animals adapted to a primatological chair (11 and 6 monkeys, respectively), with 2-h immobilization in horizontal position (13 and 8), with use of acute stress factor (8 and 5) and orthostatic test (13 and 5).

After drawing background blood samples by means of marginal scarification of the ear, for the GTT we injected in the brachial vein 40% glucose in a volume corresponding to a dosage of 1 g/kg body weight, and for the IST, insulin solution in a dosage of 0.1-0.2 U/kg weight. The interval between the tests and last food intake was 20 h. Test samples of blood were collected 15, 30, 45, 60, 90 and 120 min after intravenous injection of glucose or insulin. We calculated the coefficient of glucose elimination [6, 8] to analyze the hyperglycemia curve. The obtained data were interpreted in accordance with the classification of standard, subdiabetic states in monkeys [7], which coincides with the one used in clinical practice [5].

We determined blood glucose level after intravenous injection of an aliquot of saline as the control for the GTT and IST with immobilization in horizontal and orthostatic positions.

A turntable was used for orthostatic positioning, as well as for immobilization in horizontal position. Acute stress was produced by curarization of waking animals [2]. In all instances, the time of the test (120 min) coincided with the period for these positions. Glucose was assayed in blood samples by the standard colorimetric method using orthotoluidine dye.

Results and Discussion

In monkeys adapted to the primatological chair, the hyperglycemic curves with the GTT (Figure 1a) were characterized by a short phase of rapid (up to 45 min) assimilation of glucose to background levels and marked subsequent phase of relative, reactive hypoglycemia. In all other experimental situations (immobilization in horizontal position, acute stressor, orthostatic position) there was extension of the first phase of glucose elimination and rudimentation of the phase of reactive hypoglycemia.

Analysis of the hyperglycemic curves in semilogarithmic coordinates (Figure 1b) revealed reliable differences between the states studied according to rate of glucose elimination. The mean coefficient of elimination:

$$K = \frac{\ln 2 \times 100}{T_{\frac{1}{2}}}$$

where $T_{\frac{1}{2}}$ is half-life for glucose elimination (K = 1.8, with individual fluctuations from 1.5 to 2.2), coincided in monkeys in the primatological chair with the normal glucose tolerance according to the classification in [7]. Immobilization in horizontal position (K = 1.4) and acute stress (K = 1.06) corresponded to the characteristics of a borderline diabetic state.

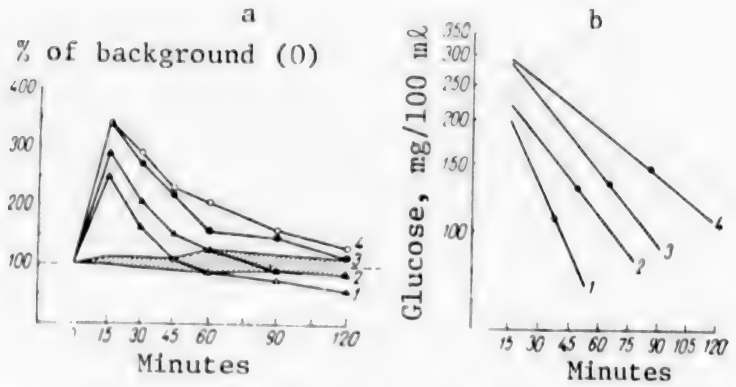

Figure 1. Hyperglycemic curves (a) and logarithmic analysis of glucose elimination (b) during GTT on Macaca rhesus in different functional states

1) primatological chair ($T_{\frac{1}{2}}$ = 39 min, K = 1.7)
2) immobilization in horizontal position ($T_{\frac{1}{2}}$ = 50 min, K = 1.4)
3) acute stressor ($T_{\frac{1}{2}}$ = 66 min, K = 1.1)
4) orthostatic position ($T_{\frac{1}{2}}$ = 85 min, K = 0.82)

An important finding was the drastic decline of glucose tolerance when the monkeys were in orthostatic position (K = 0.82). According to the exsiting unequivocal interpretation of data on glucose tolerance, its parameters coincided with the characteristics of a diabetic state in orthostatic position. At this stage of the study it was difficult to explain this fact; however, one thing is obvious: in orthostatic position there is marked decline of glucose tolerance according to the GTT. Psychoemotional stress, which exists for immobilized monkeys and in an acute stress state (curarization of a waking animal), was characterized by the same direction of findings, though to a lesser extent. Analytical comparison of the four states studied (see Figure 1) revealed that use of orthostatic position alone (primatological chair) and moderate psychoemotional tension (immobilization in horizontal position) do not alter appreciably the standard GTT characteristics. However, both these factors combined with use of orthostatic position on an animal secured to the turntable qualitatively altered the GTT characteristics and direction of decline of glucose tolerance.

It could have been assumed that such glycemia in the GTT is related to functional hyperglycemia, which could be induced by immobilization, as well as curarization and orthostatic factors. However, the results of control experiments, in which glucose was assayed throughout the period of exposure to the main factor after intravenous injection of the appropriate amount of saline revealed that this was not so.

Figure 1a shows that blood glucose content was below the background level during immobilization in horizontal position, and in orthostatic position there was a slight increase within the standard range. This warrants the belief that the observed phenomenon is based on a more complex mechanism of impairment of glucose tolerance. The existing conception that the GTT is primarily a test of vagoinsular regulation leads us to assume that psychoemotional tension and

stress states depress insulin secretion. We want to emphasize the fact that orthostatic position had a marked enhancing effect on this reaction.

As we know, insulin is one of the principal hormones involved in transport through the cell membrane of the basic energy substrate of the body, glucose. No doubt, the states we studied are energy-consuming and require a specific level of energy in body tissues. For this reason, diminished function of the insular system of the pancreas appears to be inconsistent with the increased energy demand of the body. With regard to the experiments with curarization, it can be assumed that muscular relaxation lowers significantly this demand for energy, and for this reason the slower assimilation of injected glucose reflects, to some extent, this state.

To settle this question, a study was made of insulin sensitivity of peripheral tissues with use of the above factors. For expressly this purpose, we ran the standard test for insulin sensitivity (IST).

Monkeys in primatological chairs showed a marked two-phase hypoglycemic curve (Figure 2a). Maximum hypoglycemia developed 15-30 min after insulin injection. We then observed progressive rise of blood glucose level. However, the background level was reached and exceeded only in animals, in which the test was performed during a period of minimal physiological activity (from midnight to 2 am; see Figure 2a, curve 1). Such a second phase in the hypoglycemic curve is indicative of effectiveness of the counterinsular mechanism in monkeys. Increasing hypoglycemia in the first phase (15-30 min) and less marked second phase (Figure 2b) were the general direction of the hypoglycemic effect of exogenous insulin under all other experimental conditions. We were impressed by the fact that the increase in insulin sensitivity depended on extent of general functional activity in the tested states. More marked psychoemotional tension in the morning hours (10-12 am) and in monkeys placed in primatological chairs was observed and associated with more marked hypoglycemia in the first and second phases. The second phase was even flatter in immobilized monkeys, and this was indicative of longer retention of hypersensitivity to insulin.

It must be noted that there was a reciprocal effect on endogenous insulin secretion against the background of exogenous insulin. This conclusion is based on our findings during the standard glucose tolerance test against the background of insulin hypoglycemia. Glucose was injected intravenously to 6 monkeys immobilized in horizontal position 2 h after injection of 0.2 U insulin per kg body weight.

Figure 2 shows that the start of the GTT corresponds to rather marked hypoglycemia. Against this background, we observed extension of glucose elimination half-life to 67 min and reduction of coefficient of elimination to 1.03 (Figure 3). The observed effect may reflect a decline of functional activity of the insular system, which no doubt causes triggering of mechanisms to compensate the hypoglycemia induced by exogenous insulin.

A comparison of the effects of immobilization, curarization and orthostatic tests, with regard to insulin sensitivity (dosage 0.2 U/kg) revealed some interesting distinctions (see Figure 2). Lowest insulin sensitivity was found

with curarization; in this state the phase of compensation of hypoglycemia was more marked than with immobilization of the animals. Evidently, this phenomenon is related to functional exclusion of muscles during relaxation, and they are the absolutely and relatively most energy-consuming and energy-producing tissues of the body. In orthostatic position, there was progression of hypoglycemia throughout the observation period.

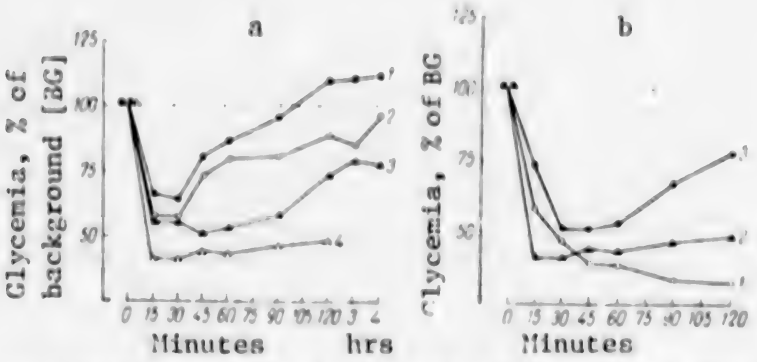

Figure 2. Characteristics of insulin hypoglycemia under different experimental conditions

a: effect of time of day and insulin dosage on characteristics
   1) midnight to 2 am
   2) 10 am to noon (in both cases 0.1 U/kg insuline, monkeys in primatological chairs)
   3) 0.1 U/kg insulin
   4) 0.2 U/kg insulin (in both cases immobilization in horizontal position)

b: effect of different factors on characteristics
   1) orthostatic position
   2) immobilization in horizontal position
   3) acute stress

The reciprocal balance demonstrated in our studies between vagoinsular regulation (diminished glucose tolerance) and change in tissue (cellular receptors?) sensitivity to insulin (increased sensitivity) in the presence of functional stress apparently constitutes the basis for the required energy supply to tissues. The decrease in functional activity of the body as, for example, in animals kept in the primatological chairs during the GTT and IST tests done at night (period of relatively minimal physiological activity) was associated with the opposite reciprocal relations: increased glucose tolerance and decreased insulin sensitivity. Impairment of such reciprocity could lead to profound regulatory disorders, such as insulin-resistant diabetes (diminished tolerance to glucose and sensitivity to insulin) and hypoglycemic coma (increased glucose tolerance and insulin sensitivity).

Marked decline of glucose tolerance according to GTT in orthostatic position, which was established as a result of our studies, is a rather important factor. The fact that the GTT parameters in orthostatic position correspond to the characteristics of a diabetic state, particularly in combination with psychoemotional tension, is indicative of the possible significance of orthostatic procedures as a risk factor for development of essential subdiabetic and diabetic states.

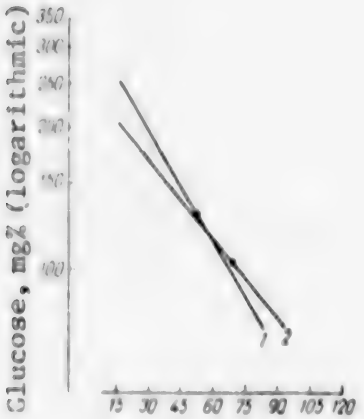

Figure 3.
Characteristics of rate of glucose elimination during GTT before (1; $T_{\frac{1}{2}}$ = 50 min, K = 1.4) and during (2; $T_{\frac{1}{2}}$ = 67 min, K = 1.03) insulin hypoglycemia in monkeys

Analysis of reciprocal relations between change in glucose tolerance and insulin sensitivity with the factors used leads us to assume that the observed changes in glucose tolerance are in the functional range of vagoinsular regulation, although it is apparently at the top of this range in the case of orthostatic position. Constant functional strain on vagoinsular regulation could disrupt it, as manifested by change in reciprocal effects to synergistic effects of vagoinsular regulation and insulin sensitivity.

It has now been shown that the mechanisms of regulating incretory function of the pancreas are rather complex, and that the nervous system is important in this regulation [1, 3, 9].

In our study, the dosage of glucose injected in all cases and, consequently, the effective level of hyperglycemia were the same. For this reason, the differences in rate of glucose assimilation and, consequently, intensity of insulin secretion would be difficult to relate only to blood glucose content. In our studies there was very distinct manifestation of the influence of different functional states of the entire neurohormonal functional system on regulation of blood glucose content. An analogous conclusion applies to hypoglycemia induced by exogenous insulin.

Our findings indicate that the combination of GTT and IST makes it possible to assess more fully the condition of two basic elements of the neurohormonal functional system of controlling glycemia--on the level of direct effect (rise in glucose level) and feedback (rise in insulin content) in this regulation. Reciprocal relations are demonstrable in the functional range of the latter. Expressly impairment of these relations may be indicative of nonspecific reflection of changes in systemic reactivity and resistance, which are the basis of diminished resistance to different factors and development of a pathological process. This conclusion is indicative of the need to use combined tests for evaluation of systemic reactivity and resistance, glucose tolerance and insulin sensitivity.

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MULTIPLE REGRESSION METHOD USED TO ASSESS ANIMAL ADAPTATION TO HYPOXIC HYPOXIA

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 6, Nov-Dec 84 (manuscript received 21 Jun 83) pp 67-69

[Article by V. V. Kustov, V. G. Litau, Yu. A. Kukushkin and S. M. Razinkin]

[English abstract from source] White mice were exposed to hypoxic hypoxia during 30 days. In the study a correlation between the altitude ceiling and various physiological parameters (body weight, body temperature variations in response to a cold stress--5°C, hemoglobin content) coefficients of adaptive oxygen consumption at 6000 m to that at sea level (K_1) and the ratio of oxygen consumption in hypoxic environment to that in a normoxic atmosphere (K_2) was established. The data obtained allow the conclusion that the multiple regression method can be used for measuring objectively the tension of regulatory systems and for discriminating stages of animal adaptation to hypoxic hypoxia.

[Text] At the present time, the level of adaptation to hypoxic hypoxia is evaluated on the basis of the state of a single or set of physiological, biochemical and hematological parameters [1, 4, 6], often without objective consideration of the relations between them.

We shall discuss here the use of the method of multiple regression for this purpose.

Methods

Experiments were conducted on 120 male mongrel white mice with initial weight of 29-30 g. The experimental group of animals was conditioned for 30 days to pressure chamber hypoxia in the following manner: the mice spent 4 h at an "altitude" of 3000 m on the 1st experimental day, 350 m on the 2d, 4000 m on the 3d, 5000 m on the 5th and 6000 m on the 6th and subsequent days.

We recorded weight of the mice, determined their "altitude" ceiling, hemoglobin in peripheral blood, took their temperature before and after 10-min cold (5-6°C) stress before the experiment, on the 15th and 30th day of conditioning to pressure chamber hypoxia, as well as 14 days after the latter.

In addition, we determined for each animal the level of adaptive oxygen uptake at an "altitude" of 6000 m and during slowly progressive hypoxia (pO_2 in the chamber was reduced to 40 mm Hg in 25 min). By comparing each of these levels to oxygen uptake under ground-based conditions, we calculated coefficients K_1 and K_2, respectively, the values of which, according to the data of G. A. Vasil'yev et al. [3], V. V. Kustov and L. A. Tiunov [5], constitute an integral indicator of functional state of the adrenohypophyseal system and, consequently, level of individual nonspecific resistance of the body to stressors.

We calculated an equation of multiple regression to demonstrate links between altitude ceiling (y) and the aggregate of parameters characterizing adaptability of mice to hypoxic hypoxia:

$$y = a_0 + a_1x_1 + a_2x_2 + a_3x_3 + a_4x_4 + a_5x_5$$

where x_1 is mouse weight, x_2 is decline of rectal temperature with cold stress, x_3 and x_4 are values for coefficients K_1 and K_2, x_5 is peripheral blood hemoglobin, a_0, a_1, ... a_5 are coefficients of regression.

Results and Discussion

The Table sums up the results of our studies. It shows that, on the 14th day after conditioning to pressure chamber hypoxia, the values of all parameters studied were virtually the same as before the experiment, which could be indicative of adequacy of this time for complete recovery of the mice.

Status of parameters studied in mice conditioning for hypoxia in pressure chamber

Parameter	Before experiment	Conditioning, day		14 days after conditioning
		15	30	
Altitude ceiling, m	9147±227	10 452±305*	10 900±226*	8752±335
K_1	0,64±0,13	0,95±0,16*	1,05±0,10*	0,64±0,10
K_2	0,63±0,14	0,70±0,.0	0,79±0,06*	0,71±0,11
Rectal temperature drop with cold stress, °C	0,67±0,2	0,95±0,2*	0,51±0,1*	0,68±0,07
Body weight, g	30,2±2,4	29,3±2,2	30,0±2,2	33,5±2,3
Blood hemoglobin, g/ℓ	168,7±0,7	159,6±0,4*	175,3±2,8*	154,9±7,8

*$P<0.05$ as compared to base level.

On the 15th day of conditioning there was considerable increase in altitude resistance of experimental mice; their "altitude" ceiling rose from 9147±227 to 10,452±305 m. There was concurrent increase in coefficient K_1, and greater body temperature drop when the animals were cooled than before the experiment. Peripheral blood hemoglobin content was somewhat low.

On the 30th day of conditioning, the experimental mice were more resistant to altitude than on the 15th experimental day: their altitude ceiling rose from

10,452±305 to 10,900±226 m, which could be attributable to a difference in level of alteration of adaptive-compensatory reactions at the compared stages of adaptation of the animals to pressure chamber hypoxia. This is proven by the fact that, by the 30th day of conditioning, along with reactions causing an increase in adaptive oxygen uptake in response to acute hypoxic hypoxia (increase in coefficient K_1), reactions involved in increased adaptive oxygen uptake with slow decline of its partial tension in inhaled air (increase in coefficient K_2) acquired substantial signficance, as did metabolic reactions involved in formation of cold resistance. This was indicated by the less marked temperature drop after the cold test than on the 15th day of conditioning. In this period, there was also development of compensatory increase in peripheral blood hemoglobin content.

For objective evaluation of degree of strain on adaptive-compensatory reactions of mice at the compared stages of their conditioning to altitude hypoxia, the experimental results were submitted to analysis by the method of multiple regression.

The results of solving the relevant equations are submitted below.

On the 15th day of conditioning, the animals' altitude ceiling (V) as a function of the sum of other parameters studied was described by the following equation:

$$y = 25397 - 228x_1 + 16x_2 - 2018x_3 - 9591x_4 + 30x_5$$

The coefficient of multiple correlation R and F criterion of Fisher constituted 0.81 and 5.63, respectively ($P<0.01$).

On the 30th day of conditioning, the regression equation acquired the following appearance:

$$y = 7534 - 31x_1 - 656x_2 + 2315x_3 + 4390x_4 - 74x_5;\ R = 0.51;\ F = 1.0\ (P>0.05)$$

In the opinion of several researchers [2, 7, 8], the decreased matching of elements of the functional system, their poorer synchronization and attenuation of correlations between them are an objective sign of stress and even depletion of the body's regulatory systems.

Assessing the results of our studies from this vantage point, we can state that full (persistent) adaptation of animals to pressure chamber hypoxia develops (with the conditioning protocol we chose) by the 15th day of the experiment. This stage of adaptation apparently changes into the stage of unstable adaptation by the 30th day of conditioning, and it is characterized by a strain on regulatory systems. The changes in coefficients of multiple regression reflect these processes and can be used for objective evaluation of strain on regulatory systems and differentiation between stages of animal adaptation to pressure chamber hypoxia.

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EFFECT OF HIGH AMMONIA CONTENT IN CLOSED ENVIRONMENT ON SOME PARAMETERS OF HUMAN NITROGEN AND CARBOHYDRATE METABOLISM AGAINST BACKGROUND OF A CONTROLLED DIET

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 6, Nov-Dec 84 (manuscript received 3 May 83) pp 69-73

[Article by A. K. Sivuk, L. I. Mosyakina, N. A. Malevskaya-Malevich, I. A. Ul'yanova, Ye. A. Sedova and A. N. Kravchuk]

[English abstract from source] This paper presents data on nitrogen and carbohydrate metabolism in men kept in an enclosed environment with a high ammonium content (2 and 5 mg/m^3) combined with a high temperature and humidity. The toxic environmental effect manifests itself when the ammonium concentration increases up to 5 mg/m^3 in combination with a high temperature and humidity level. During this period protein catabolism and negative nitrogen balance enhance. It is recommended that vitamins should be added to the diet used under the above conditions.

[Text] At the present time it has been shown that when a man spends time in a sealed environment there can be accumulation of ammonia in the atmosphere as a result of vital functions.

Several works reported adverse metabolic changes in man and animals under the effect of different concentrations of ammonia [3, 9, 10, 12]. Proceeding from these data, we set as our goal a study of parameters of nitrogen and carbohydrate metabolism in individuals placed in a closed environment with high levels of ammonia and with a combination of the latter with high ambient temperature and humidity.

Methods

We studied 2 groups of male subjects (4 in each group) who spent 20 days in a sealed environment. The concentration of ammonia in the chamber was raised to 2 mg/m^3 (1st group) and to 5 mg/m^3 (2d group) from the 6th to 15th days. In addition, we raised temperature (to 33°C) and humidity (to 90%) on the 9th-15th days of the study.

The subjects' diet consisted of a food allowance prepared for 3-day periods, with 4 meals per day. The diet included foods preserved by the sterilization

Table 1. Dynamics of excretion of end products of nitrogen metabolism and nitrogen balance (g/day) in subjects exposed to 2 mg/m^3 ammonia in pressure chamber (M±m)

Parameter	Background	Days in pressure chamber					
		4–5	6–8	9–11	12–14	16–18	19–20
Total N	12,6±1,20	14,0±0,46	12,4±0,46	11,3±0,48	9,2±1,13	9,6±1,12	11,2±1,27
Urea	22,2±1,66	21,0±2,55	25,5±0,80	22,1±0,69	17,7±1,98*	17,6±1,85**	20,7±2,56
Ammonia	0,93±0,077	0,88±0,078	1,09±0,023	0,96±0,041	0,72±0,081	0,76±0,053	0,88±0,085
Uric acid	0,37±0,030	0,47±0,075	0,43±0,065	0,50±0,027**	0,28±0,025	0,60±0,042**	0,78±0,049***
Creatinine	1,69±0,091	1,46±0,208	1,76±0,347	1,97±0,095	1,54±0,058	1,65±0,118	1,76±0,[illegible]
N balance	—1,80	—3,34	—1,58	—0,37	+1,94	+1,50	—0,26
Diuresis 24-h, ml	784,9±42,7	826,2±86,4	882,5±53,6	746,4±87,6	491,7±42,5**	811,6±42,3	800,0±97,8

* $P<0,05$.
** $P<0,02$.
*** $P<0,001$.
**$P<0,01$.

method (first and main courses, dessert, beverages) and confections packed in polymer. One Undevit [vitamin] lozenge was to be taken with breakfast and lunch daily. The amounts of principal nutrients in the average daily food allowance were as follows: protein 84 g, fats 109.8 g, carbohydrates 353.0 g (1:1.3:4.2 ratio), ash 22.2 g and caloric value 2648.0 kcal (11087.2 kJ).

We evaluated nitrogen metabolism by the level of total nitrogen, ammonia [8], urea [14], creatinine [13] and lactic acid [7] excretion in urine; we tested blood for fasting sugar [11] and amylase activity [2]. Determination of parameters of nitrogen metabolism was made in an average 24-h urine sample collected for 3 days (in accordance with the meal schedule); sugar concentration and amylase activity in blood were determined on the 5th, 8th, 15th and 20th days.

Results and Discussion

Our studies revealed that the parameters of nitrogen metabolism, blood glycemia and amylase activity were within the range of the conventional physiological norm throughout the period of the study. However, the dynamics of the parameters tested were related to changes in parameters of the environment.

The subjects of the 1st group retained the base values for excretion of end products of nitrogen metabolism for the first 3 days (Table 1). We only observed insignificant decrease in creatinine excretion (from 1.69±0.091 to 1.46±0.208 g/day ($P>0.05$), which was probably due to the relative restriction of motor activity. Blood sugar concentration at this time exceeded somewhat the background values (102.0±5.0 mg%, background 91.0±5.0 mg%; $P>0.05$) and amylase level was unchanged (Table 2).

The increase to 2 mg/m^3 in concentration of ammonia in the chamber atmosphere for the next 3 days led to some increase in urea

excretion (from 22.2±1.66 to 25.5±0.80 g/day; P>0.05) with retention of base values for urea nitrogen/creatinine nitrogen (UN/CN) ratio. The parameters of carbohydrate metabolism also failed to differ from the initial values.

Table 2. Dynamics of glycemia (mg%) and blood amylase activity (%) in subjects when ammonia level in chamber environment is high (M±m)

Ammonia concentr. mg/m^3	Parameter	Background	Days in pressure chamber			
			1–5	6–8	9–14	15–20
2,0	Blood sugar	91±1,5	102±5,0	95±1,6	105±6,5	86±6,8
	Amylase	11±0,7	11±2,0	14±1,4	9±0,5	9±0,3
5,0	Blood sugar	90±6,2	111±6,6	117±2,7*	114±5,9	110±0,0
	Amylase	10±1,1	9±0,5	10±1,5	16±0,5*	10±0,4

* $P<0,01$.

Elevation of temperature and ambient humidity during inhalation of ammonia (2 mg/m^3) led to decrease in excretion of total nitrogen, urea (P>0.05) and UN/CN. Evidently these changes were related to the effects of high temperature and humidity, which was associated with poorer appetite, decrease in protein intake, significant decline of 24-h diuresis and excretion of total nitrogen and urea (see Table 1). During the same period (7-day stay in chamber with combined exposure to ammonia, high temperature and humidity) the subjects presented increase in blood sugar concentration from 95.0±1.6 to 105.0±6.5 mg% (P>0.05; see Table 2). There was also some increase in blood amylase activity, which could have been related to the need for increased utilization of carbohydrates taken with food and mobilized from the liver [1, 15].

Subsequently (on 19th-20th day), there was a tendency toward return of most tested parameters to background values. By this time there was considerable improvement of the subjects' appetite. They either presented a positive nitrogen balance or nitrogen equilibrium. However, it should be mentioned that there was an increase in uric acid excretion between the 16th and 20th days (discontinued ammonia inhalation), as compared to the last days of inhalation. Evidently, under the combined effect of ammonia, high temperature and humidity there was depression of mechanisms of production or elimination of uric acid. It should be noted that these changes were reversible.

In the second group of subjects, the parameters of nitrogen metabolism and amylase activity remained normal when they stayed in the pressure chamber at normal ambient parameters. However, sugar concentration was somewhat above the base values (114.6±6.6 mg% versus the base level of 90.0±6.2 mg%), which was apparently related to the reaction to the start of the experiment.

Inhalation of ammonia in a concentration of 5 mg/m^3 had virtually no influence on excretion of end products of nitrogen metabolism (Table 3), whereas the glycemia level had a tendency toward rising (see Table 2).

Combined exposure to ammonia, high temperature and humidity for the first 3 days led to increase in excretion of total nitrogen to 15.7±0.98 g/day

Table 3. Dynamics of excretion of end products of nitrogen metabolism and nitrogen balance (g/day) in subjects exposed to 5 mg/m^3 in pressure chamber (M±m)

Parameter	Background	Days in pressure chamber					
		4-5	6—8	9—11	12—14	16—18	19—20
Total N	10,5±0.21	10,3±0,53	9,7±1,31	15,7±0,98*	11,3±0,36	[illegible]	[illegible]
Urea	18,5±0,54	19,1±0,98	17,8±3,47	30,0±2,29**	19,9±1,38	26,1±4,14	20,2±2,51
Ammonia	0,82±0,032	0,76±0,034	0,80±0,130	1,15±0,088*	0,89±0,039	1,04±0,085	0,84±0,116
Uric acid	0,49±0,010	0,41±0,040	0,52±0,105	0,70±0,091	0,70±0,030***	0,49±0,090	0,58±0,120
Creatinine	1,84±0,035	1,81±0,069	1,32±0,130*‡	1,92±0,065	1,84±0,036	1,60±0,160	1,14±0,110***
N balance	+0,51	+0,53	+1,39	—5,21	—0,37	—3,01	—0,04
Diuresis, 24-h, ml	932.1±48.6	826,2±58,8	778,0±24,7	809,9±63,9	730,0±53,5	845,0±119,0	852,5±59,2

* $P<0.05$.
** $P<0,02$.
*** $P<0,001$.
*‡ $P<0,01$.

(P<0.05). urea to 30.0±2.29 g/day (P<0.02), ammonia to 1.15±0.088 g/day (P<0.05) and uric acid to 0.70±0.091 g/day (P>0.05), with increase of UN/CN ratio from 10.1 (base level) to 16.0 (P<0.05). At the same period the blood sugar concentration and amylase activity remained high, and a negative nitrogen balance was established (-5.21 g/day). Such changes could be related to manifestation of the toxic effect of ammonia. Thus, in the studies of I. M. Alpatov [6], it was demonstrated on animals that ambient temperature elevation to 38-41°C enhanced the toxic effect of ammonia by 3 times. V. I. Mikhaylov [5, 6] reports that inhalation of ammonia in a concentration of 13 mg/m^3 is associated with accumulation of urea and elevation of blood sugar, increased excretion of urea and ammonia in urine, decrease in coefficient of oxygen utilization in tissues. Probably, in our studies, the high temperature and ambient humidity in the chamber were instrumental in manifestation of the toxic effect of ammonia in a concentration of 5 mg/m^3.

On subsequent days of the study (12th-14th), there was apparently systemic adaptation to the environmental conditions due to intensification of processes compensating for the toxic effect of ammonia. During this period such parameters as excretion of total nitrogen, urea, ammonia, UN/CN and nitrogen balance came close to base levels. Blood sugar remained somewhat high. As in the first group of subjects, uric acid excretion also increased in this period. Probably, in the case of combined exposure to ammonia in a concentration of 5 mg/m^3, high temperature and humidity, there are changes in filtration of uric acid in the kidneys. On the other hand, it may be that, under such conditions, there is impairment of mechanisms of resynthesis of nucleosides at the stage of their phosphorylation due to inadequate production of endogenous macroergic compounds [3].

On the following days (16th-20th) of stay in chamber with a comfortable microclimate,

there was a tendency toward normalization of all tested parameters. It is only in the period from thr 16th to 18th days that there was statistically unreliable increase in excretion of total nitrogen, urea, ammonia and blood sugar concentration, which was apparently related to processes of readaptation to normal ambient parameters, state of neuroemotional tension that usually was associated with the period of termination of the experiment.

Thus, the results of our studies revealed that some changes occurred in parameters of carbohydrate and nitrogen metabolism when subjects were exposed to the combination of ammonia, high temperature and humidity. The most marked changes in nitrogen metabolism were demonstrated when the ammonia concentration in the pressure chamber constituted 5 mg/m^3. Establishment at this time of a negative nitrogen balance and its persistence almost to the end of the experiment could be indicative of intensification of protein catabolism. The results of several studies revealed that, in the case of ammonia poisoning, there is impairment of transamination of amino acids and depression of Krebs' cycle due to binding of ammonia with keto acids. In addition, ammonia is capable of inactivating enzymes, either directly [3] or indirectly by impairing Mg and P metabolism [4]. All this could lead to depression of the anabolic phase of protein and carbohydrate metabolism, with development of a shortage of macroergic compounds in cells.

Ammonia inhalation increases the body's vitamin requirements. L. M. Shafran [16] has shown that exposure of man to an atmosphere containing 20 mg/m^3 ammonia leads to decline of blood vitamin C level, decrease in its excretion in urine, increase in excretion of pyruvic acid by almost 3.5 times. We interpret this as evidence of inadequate intake of vitamins C and B_1. Consequently, when ammonia content of closed environments is 5 mg/m^3 and if this is combined with high ambient temperature and humidity, we can recommend additional vitamin supplements to the diet as a preventive measure to maintain a normal level of carbohydrate and nitrogen metabolism.

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MODEL OF INFORMATION-REFERENCE DIALOGUE SYSTEM FOR WORKING WITH DOCUMENT ABSTRACTS

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 6, Nov-Dec 84 (manuscript received 9 Jun 83) pp 73-76

[Article by O. N. Rustam'yan and V. K. Vasil'yev]

[Text] Development of progressive technology for information processing is one of the most important directions of refining management work. At the same time, these measures help develop an efficient system of circulating documents, unifying and standardizing the format of documents, using progressive methods of management, which is also important to public health care.

We shall discuss here questions related to development and trial operation of a model of an information-reference dialogue system (DISS) for use with files of documents that have an hierarchic structure. The purpose of the model is to obtain a simplified DISS circuit on a YeS-1033 computer in order to define user requirements as to organizing dialogues from the technical and informational points of view.

The need to develop a DISS is due to the inadequate efficiency of manual processing of the increasing flow of information (abstracts of scientific research works, diverse standards-related documents, information about methods of running processes, etc.) because of the expansion in volume of documents.

Use of the dialogue mode has the following advantages [2]: the user can search for information himself; the interval between inquiry and response is minimal; further development of the dialogue mode will make it possible to reduce the quantity of documents on paper.

The conceptual scheme of the DISS is illustrated in Chart 1. The input flow of information consists of new documents and inquiries for concrete information. The purpose of the system is to store large volumes of information and allow for direct search upon request.

One of the elements in this system is the information group, which receives, records, processes and classifies the documents. The work of this group results in an array of data cards, from which information is inputted in the computer.

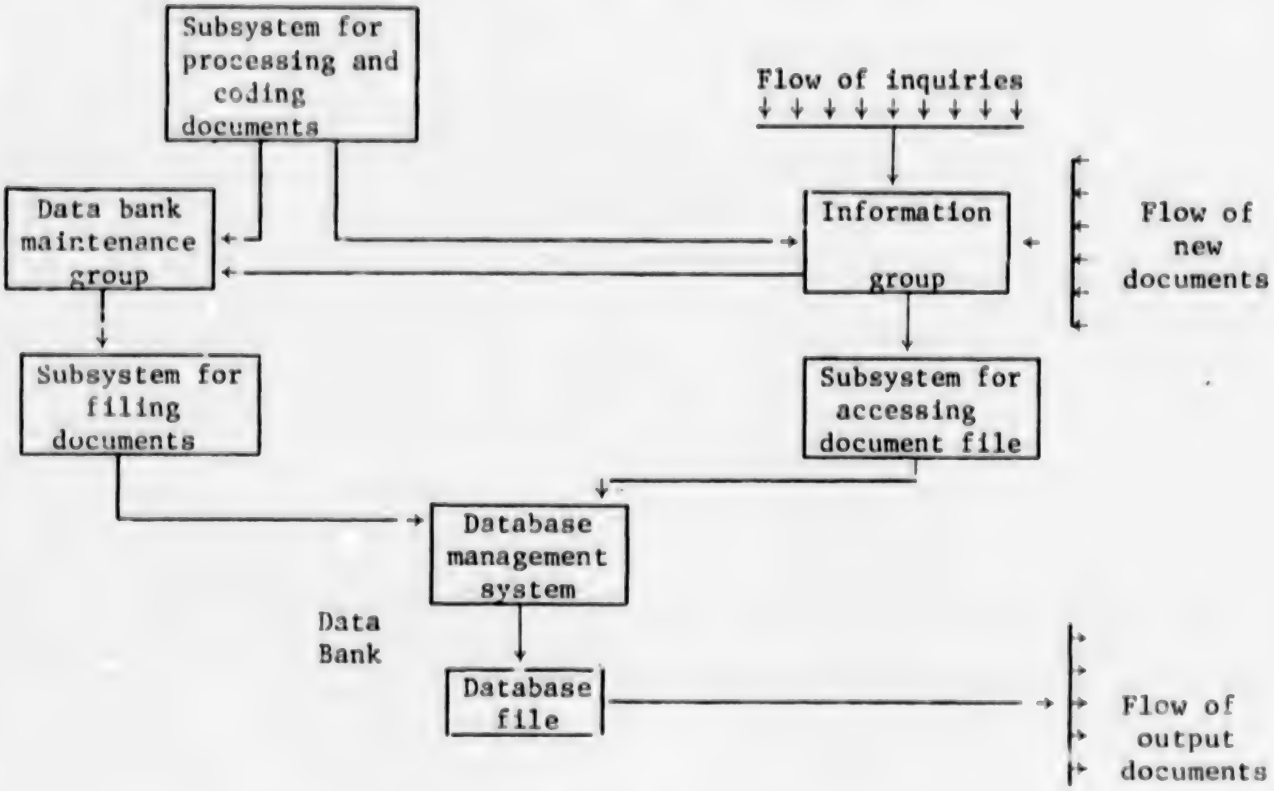

Chart 1.

The subsystem for processing and coding documents implements matching of the diversity of input documents with their computer patterns stored in the computer memory. This subsystem is the deciding one for choice of logic structure of data and database management system, which connects the information group with the data bank maintenance group.

Another element of the system is the data bank maintenance group, which receives the data cards, checks how they are filled out and implements input in the YeS computer.

The third element consists of the YeS computer and packages of programs that operate the system. Interaction with the DISS is effected through a display by means of alternative dialogue.

Formation of the database and hardware for its management does not yet solve entirely the problems of direct access to information. Mandatory elements of the system include subsystems that implement and match man-machine contacts. This refers to the subsystem for keeping the computer file of documents and subsystem for requesting information, which control protection of data, integrity of the files, inputting files and procedure for accessing the DISS for information users.

The data bank is the core of the DISS and consists of two parts, combined in a single software-hardware complex, which includes the database management system and the database.

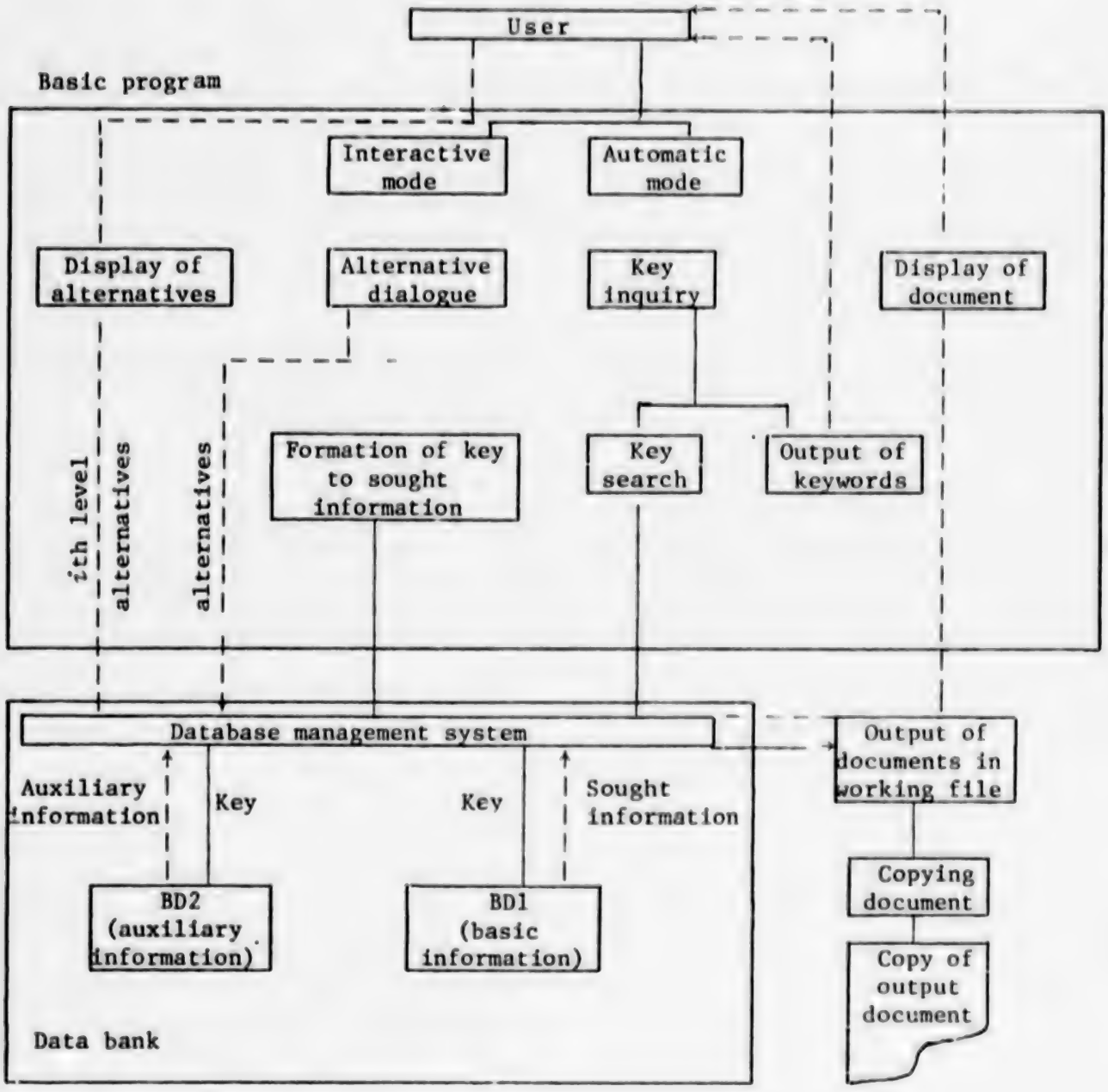

Chart 2.

The functional tasks for the DISS are determined by the purpose of the system and they are divided as follows:

1) Processing and coding documents for the computer file. This solves the problem related to retrieval of needed information from the original documents and preparing it in a form that is suitable for input in the computer.

2) Keeping the computer files. This task involves reorganization of the database, which includes entry of new documents, correction and removal of obsolete documents. This is one of the most important features of databases [7].

3) Search for documents in computer files. There are two retrieval modes--automatic and interactive--for this central task, which determines the efficiency of the system as a whole.

4) Control of access to computer files. This makes it possible to control access to the system and prevent unauthorized use of information.

In developing the DISS attention is devoted primarily to the information, which is the aggregate of input (primary), output and intermediate (auxiliary) documents. The information software of the DISS, which is also called information base, consists of the following: information model of object, logical description of structure of information, standardized forms of documents, computer arrays of basic and auxiliary information.

Logic structures are used to build the database, for example, on the order of hierarchic files, tree or grid structures [7]. The hierarchic structure developed for the DISS model has seven levels.

The input document is a tangible thing on paper, which contains information written up in the established way and that has legal validity [6]. The typical distinction of input documents is their wide diversity and unsuitability for direct input in a computer. In the DISS model, information cards (for basic abstract information) and retrieval specifications (for inquiries to DISS) are the primary documents for input of information in the computer. The information cards may contain data referable to two types of abstracts [3]. An informative abstract contains data retrieved directly from a document. A directive abstract contains the title of a document, its brief description and location. In designing informative cards, we used the tabular form. The specific requisites were entered on the appropriate lines or columns. The data on the informative cards are inputted in computer storage for repeated use in solving different problems of the information and reference type.

Chart 2 illustrates interaction between the user and DISS model. The computer data arrays consist of basic and auxiliary arrays. The basic array (BD1) contains information for permanent storage and consists of an aggregate of data intended for use as base information to solve information-reference problems. Auxiliary arrays (BD2) contain information used to organize dialogue. These are arrays of alternatives and labels for each structural level. In the case of alternative dialogue, the user successively scans all levels of the structure with the computer. At each structural level two to four alternatives are offered. The choice of the first one makes it possible to obtain general information on the corresponding level. The next numbered alternatives provide for continued search for information. Choice of the last alternative permits obtaining information on all underlying levels. BD1 and BD2 in the DISS model are simulated by structures in the direct-access memory of the YeS computer.

In addition to BD1 and BD2, one uses an intermediate array which is called the search key. The search key, which consists of the numbers of the chosen alternatives is either formed in the course of dialogue, or is inputted

together with the inquiry information card when operating in the automatic (package) retrieval mode (Chart 3).

```
  Select operating mode
   1. Dialogue
   2. Automatic
1 <answer>
```

a

```
  What interests you?
   1.  List of space flights
   2.  Missions with participation of socialist countries
   3.  Missions with participation of capitalistic countries
   4.  All flights
2  <answer>
```

```
  Spaceflights with participation of socialist countries
   1. GDR
   2. Polish People's Republic
   ...........
```

```
  Select operating mode
   1. Dialogue
   2. Automatic
2  <answer>
```

b

```
  Input search key
  212221 <content of inquiry: Data about flight of cosmonaut from GDR
  3. Jaehn>
```

```
  Output document
  Spaceflight with participation of GDR
  Cosmonaut: 3. Jaehn
  Date of mission: 26 August 1978
  Soviet cosmonauts: V. F. Bykovskiy
  Scientific research performed:
  1.
  2. . . . . .
```

Chart 3.

The software for the DISS model consists of a set of program modules that run its different functions. The basic functions of program modules are reflected on the chart of interaction of user with DISS model. PL/1 was

selected as the basic programming language, because it has the means for formal description of multilevel hierarchic structures of data. If necessary the PL/1 language is supplemented with Fortran and Assembler as auxiliary programming aids. In the DISS model, we used some of the systems programs developed by V. K. Vasil'yev and I. B. Kozhevnikov [1].

The output documents are the system's answers, which are printed on the output unit of the computer as copies of display frames.

A technological process has been developed that reflects the order of the operations for computer processing of information with use of the DISS, starting with receipt of initial documents and ending with output of the answer to an inquiry in dialogue or automatic mode.

A preliminary estimate was made of the economic effectiveness of a typical technological process for input and retrieval of information upon request in order to assess the technical and economic expediency of developing and introducing the DISS. The estimate was made on the basis of conventional methods [4, 5]. We took the manual method of processing and searching for documents as the basic technological process and the computer method for input and retrieval of information upon request as the proposed one. Estimation of economic efficiency revealed that labor is reduced to one-fifth and cost to two-sevenths with use of the DISS.

Making the model of an interactive information-reference system enabled us to define the specifications for development of a system of this type for the purpose of developing DISS for a number of ongoing tasks with filed documents at sections of the Institute.

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SPIROLIT-2 INSTRUMENT USED TO TEST PULMONARY VENTILATION

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 6, Nov-Dec 84 (signed to press 15 Jun 83) pp 76-77

[Article by V. V. Zhuravlev]

[Text] At the present time, the Spirolit-2 automatic analyzer of main respiratory gases, of the Junkalor Dessau firm, is used to examine parameters of gas exchange, levels of energy expended by man and animals with different degrees of activity. However, the capabilities of this model of the instrument are limited, and they do not permit evaluation of pulmonary ventilation, on the basis of which one can calculate additional parameters to assess the economy and efficiency of respiration [1, 3].

In the absence of spirographs, heretofore a method has been used to collect exhaled air in rubberized bags for determination of pulmonary ventilation. The volume of air collected within a fixed time is measured with gas meters. Part of the exhaled air is analyzed for oxygen and carbon dioxide content. No doubt, the intermediate stages complicate examination of respiratory function and contribute additional errors to the results obtained. The last comment applies in particular to cases of testing external respiration under the special conditions of sealed rooms.

For this reason we developed, tested and are recommending a method of determining pulmonary ventilation with use of the Spirolit-2, for which purpose we built into the usual valve box (see Figure) an additional exhalation valve *3* with a duct, to which an anesthesia machine rubber bag, 2-3 ℓ in capacity, is attached. Resistant to air flow of valves *2* and *3* should be about the same, so that exhaled air passes evenly through these valves. Samples are collected into bag *4* concurrently with the usual tests on the Spirolit-2 instrument. Four to five minutes are sufficient to obtain stable parameters at relative rest of oxygen uptake, determine carbon dioxide output per minute and collect samples in bag *4* for analysis of exhaled air.

The proposed method can furnish information about the dynamics of development of respiratory function of the lungs at virtually any moment with a constant physical load. For this, there must be spare bags to collect samples. One can obtain stage-by-stage data analogously as to ventilation volume during a step test while determining maximum oxygen uptake. Analysis of the

Human minute respiratory volume at relative rest and during work of different intensity (M±m)

Parameter	$\dot{V}_E$ when breathing under ordinary conditions			$\dot{V}_E$ when breathing air with up to 0.9% CO_2			$\dot{V}_E$ when breathing air with up to 3.8% CO_2		
	relative calm, mℓ/min	load		relative calm, mℓ/min	load		relative calm, mℓ/min	load	
		50% of $\dot{V}O_2$ max. ℓ/min	75% of $\dot{V}O_2$ max. ℓ/min		50% of $\dot{V}O_2$ max. ℓ/min	75% of $\dot{V}O_2$ max. ℓ/min		50% of $\dot{V}O_2$ max. ℓ/min	75% of $\dot{V}O_2$ max. ℓ/min
M±m n	5032±177 22	25,2±0,45 16	38,7±0,65 14	7478±138,9 24	26,53±0,983 4	37,5±1,01 4	14,77±1,365 12	50.55±5.225 4	71.98±5.421 4

Note: Minute volume parameters ($\dot{V}_E$) were scaled to standard conditions (STPD)

collected air samples is performed immediately after the Spirolit-2 test by the usual method. With proper selection of resistance of exhaling valves 2 and 3, respiratory coefficients (R) used to determine the amount of oxygen taken up per minute and carbon dioxide output, as well as percentage of oxygen and carbon dioxide in the sample, should not differ by more than 0.01 units.

Modified valve box (diagram)
1) valve box housing
2,3) expiration valves
4) bag for exhaled air samples

One of two formulas are used to calculate pulmonary ventilation:

$$\dot{V}_E = \frac{\dot{V}_{O_2} \times 100}{\Delta FeO_2} \text{ (I) or}$$

$$\dot{V}_E = \frac{\dot{V}_{CO_2} \times 100}{\Delta FeCO_2} \text{ (II),}$$

where $\dot{V}_E$ is minute respiratory volume, $\dot{V}_{O_2}$ and $\dot{V}_{CO_2}$ are oxygen uptake and carbon dioxide output per min, ΔFeO_2 and $\Delta FeCO_2$ are O_2 deficit and increase in CO_2 in exhaled air (%).

Example of calculation of $\dot{V}_E$:

The following was determined:

$\dot{V}_{O_2} = 240$ mℓ $\quad \Delta FeO_2 = 4{,}45$ %

$\dot{V}_{CO_2} = 208$ mℓ $\quad \Delta FeCO_2 = 3{,}85$ %

$R = 0{,}867$ $\quad R = 0{,}865.$

Hence

$$\dot{V}_E = \frac{\dot{V}_{O_2} \times 100}{\Delta Fe_{O_2}} = \frac{240 \times 100}{4{,}45} =$$

$$= 5393 \text{ mℓ/min} \qquad (1)$$

$$\dot{V}_E = \frac{\dot{V}_{CO} \times 100}{\Delta FeCO_2} = \frac{208 \times 100}{3{,}85} =$$

$$= 5403 \text{ mℓ/min} \qquad (2)$$

This example is the ideal case, which is indicative of the validity of using the proposed method for measuring pulmonary ventilation. In practice, when well-matched valves are used, one of the above-listed formulas, (1) or (2) can be used.

The Table lists minute respiratory volumes obtained experimentally with the proposed method under different conditions.

In analyzing the data in this table, it should be noted that the parameters of pulmonary ventilation obtained by the above method correspond to data in the literature [2, 4]. Thus, the described method of determining ventilation parameters may find application at medical and other research institutions that have the Spirolit-2 instrument.

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BRIEF REPORTS

UDC: 629.78:[612.396+612.128

PARAMETERS OF CARBOHYDRATE METABOLISM AND BLOOD SERUM ENZYME ACTIVITY AFTER SHORT-TERM SPACEFLIGHTS

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 6, Nov-Dec 84 (manuscript received 9 Sep 83) pp 78-79

[Article by I. A. Popova, T. Ye. Drozdova and Ye. G. Vetrova]

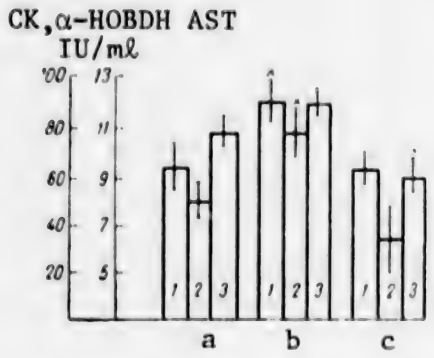
[Text] The preliminary results of biochemical tests made after each spaceflight constitute a complex picture of diverse and sometimes contradictory changes in most biochemical parameters of blood and urine, as compared to preflight values. The distinctive individual reactions of cosmonauts play some part in this. Statistical analysis of the aggregate of data obtained from visiting missions (VM) of the Salyut-6 scientific space complex, which varied in duration, makes it possible to assess with great reliability the patterns of reactions to brief weightlessness.

Methods

After each of the 10 VM, as well as in the background tests on VM crews, traditional venous blood (serum, protein-free filtrate) tests were performed; determination was made of substrates in blood and products of carbohydrate metabolism, as well as of blood serum enzyme activity. The biochemical tests were performed 30 days before flights, as well as on the 1st and 7th-14th days after the VM. Enzymospectrophotometric methods, with standard sets of reagents of the Beringer firm (FRG), were used to measure activity of aspartate aminotransferase (AST), alanine aminotransferase (ALT), creatine kinase (CK), isocitrate dehydrogenase (ICDH), lactate dehydrogenase (LDH), α-hydroxybutyrate dehydrogenase (α-HOBDH), alkaline phsophates (AP), malate dehydrogenase (MDH), as well as to assay glucose, lactic and pyruvic acids. The isozyme composition of AP was studied by thermal inactivation [5], while the spectrum of LDH isozymes was demonstrated by electrophoresis in polyacrylamide gel.

Results and Discussion

We failed to demonstrate reliable changes in parameters characterizing carbohydrate metabolism in the cosmonauts after VM. Blood levels of glucose, lactic and pyruvic acids did not differ from the mean statistical control, either on the first postflight day or on the 7th-14th days of the recovery period.



Blood serum enzyme activity in VM crews of Salyut-6 space complex
X-axis, time of examination;
y-axis, activity level (M±m) of AST (1), CK (2) and α-HOBDH)

a) preflight
b, c) 1st and 7th-14th postflight days, respectively

*P<0.001

Of all the tested blood serum enzymes, only two presented reliable increase in activity, AST and CK, on the 1st postflight day, as compared to the control (see Figure). Clinical observations revealed that an increase in blood AST activity is a sensitive indicator of metabolic and structural changes in myocytes or myocardiocytes, and it indicates that there is parenchymatous liver deficiency [3]. However, in the case of organic pathological changes, blood enzyme activity is usually considerably above normal. Although the increase in activity of these enzymes was reliable in the cosmonauts, it was within the range of normal values. In addition, with pathological changes in organs there is often synchronous change in all enzymes referable to a given organic constellation. For the liver it is the set of enzymes that includes, in addition to AST, ALT, MDH, ICDH and AP. LDH and particularly its isoform, LDH_1, is an important diagnostic component of the cardiac constellation of serum enzymes. Since we failed to demonstrate any significant changes after the VM in activity of the above-mentioned enzymes, the question of structural or metabolic changes in the myocardium or liver can be ruled out. Probably, in this case there are other sources and mechanisms of onset of AST and CK hyperenzymemia. The most probable ones are changes in skeletal muscles. Indeed, total CK activity in blood is determined to a significant extent by an enzyme of muscular origin. There are reports to the effect that serum enzymes, including transaminases and CK, increase as a result of an excessive muscular exertion [1, 2, 4]. Such strain could occur in the first moments of returning to earth's gravity after weightlessness.

As can be seen in the figure, the high AST and CK activity observed postflight reverted to normal by the 7th-14th day, reaching the mean statistical control levels. At the same time, there was reliable decrease in blood α-HOBDH activity on the 7th-14th day of the recovery period. Decreased passage of enzyme into blood from tissues or its more intensive elimination through the kidneys could have been causes of the hypoenzymemia observed in this period.

Thus, the reliable change in activity of three blood serum enzymes--AST, CK and α-HOBDH--in cosmonauts after completing space missions (8-14 days) is indicative of changes in systems that provide a normal enzymemia level. Since the level of blood enzyme activity is the integral result of the correlation between such processes as rate of enzyme synthesis in tissues, their passage into blood from different organs and rate of elimination from plasma, the question of which of the above processes change under the influence of spaceflight factors cannot be answered unequivocally at this time, and it requires further investigation. It is also unclear which factors (weightlessness or return to earth's gravity) caused changes in AST and CK activity demonstrated

1 day after landing. This question can only be answered after biochemical tests are made of material obtained during spaceflights.

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RESULTS OF SANITARY-MICROBIOLOGICAL STUDIES ABOARD COSMOS-936 AND COSMOS-1129 BIOSATELLITES

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 6, Nov-Dec 84 (manuscript received 17 Jan 83) pp 79-81

[Article by V. I. Korol'kov, A. N. Viktorov, L. N. Petrova, V. M. Knyazev and K. V. Stelingovskiy]

[Text] The studies conducted aboard biological satellites of the Cosmos series were oriented toward investigation of mechanisms of changes in physiological functions of experimental animals under the effect of spaceflight factors. It was important to rule out any factors affecting the quality of these experiments, including the microbial one [1-6].

For this reason, studies were made of the automicroflora of the integument of experimental animals (Wistar rats) and microflora of the environment aboard Cosmos-936 and Cosmos-1129 biosatellites, as well as mockups in order to obtain base data for development of special epidemic-control measures to assure the "purity" and accuracy of biological and physiological experiments. Information about the microbiological status of experimental animals is also necessary for a fuller evaluation of their functional state under spaceflight conditions.

Methods

A set of sanitary and hygienic measures was performed before the spaceflight and start of synchronous control experiment on the ground, which included mechanical cleaning, use of ultraviolet light, as well as treatment with 70% ethyl alcohol of the inside surfaces of Cosmos-936 and its mockup. The surfaces of Cosmos-1129 and its mockup were treated with washcloths soaked with 0.1% catamine AB in aqueous solution.

We collected samples of microflora from the interior of Cosmos-936 and its mockup from five different regions ... [omission in source] ...of Cosmos-1129, and from 3 regions of its mockup, each 50 cm^2 in size. The material was collected by the washings method, which is conventional in sanitary bacteriology. During the synchronous ground-based experiment, we examined the microbial contamination of the air environment of the Cosmos-1129 mockup. Material was taken from 4 rats flown in Cosmos-1129 and 4 from the synchronous experiment

from their oral mucosa and a section of fur (interscapular region) by means of sterile cotton sponges. Samples taken from the animals' integument and inside surfaces of Cosmos 936, Cosmos-1129 and their mockups before the experiments and after their completion, were shaken in 2.0 ml sterile saline. The material was inoculated on the surface of Hottinger's 5% blood agar, Endo and Sabouraud media. Dishes with cultures were incubated at 37°C to grow bacterial flora and at 30°C to grow microflora. We then counted the number of colonies of microorganisms, identified the isolated cultures according to their morphological and biochemical properties.

Results and Discussion

The results of examining the microflora isolated from the inside surfaces of Cosmos-936 and its mockup in the synchronous ground-based experiment are listed in Table 1. It should be noted that primarily staphylococci and micrococci were demonstrated preflight on all of the tested sections of the interior. There was a decline in level of microbial contamination of most interior surfaces of Cosmos-936 and its mockup after the spaceflight and termination of synchronous experiment. There were changes in species composition of microflora, as manifested by increase in relative number of Gram-positive bacilli on interior surfaces.

Table 1. Microbial contamination of internal surfaces of Cosmos-936, Cosmos-1129 and their mockups

Experiment	Cosmos-936		Cosmos-1129	
	preflight	postflight	preflight	postflight
Flight	10^{1}-[illegible]	10^{1}-10^{2}	0-10^{1}	0-10^{1}
Synchronous control	0-[illegible]	0-10^{3}	0-10^{2}	0-10^{1}

Note: Figures show microorganisms on different interior surfaces (per 50 cm^2).

Table 2. Microbial contamination of air in Cosmos-1129 mockup

Parameter	Day of experiment			
	1	9	16	18
Total quantity of microorganisms	1000	250	1000	1400
Share of epidermal staphylococci	>10	>10	1000	1000

Note: Figures show microorganisms per m^3 air.

The study of microflora aboard Cosmos-1129 revealed that preflight contamination was considerably lower on interior surfaces of this spacecraft than on the interior of Cosmos-936 (see Table 1). Microorganisms were found only on one of three tested sections of the interior, and they consisted exclusively of nonpathogenic staphylococci. After the flight, there was appearance of representatives of Gram-negative flora (Achromobacter anitratus) referable to so-called water saprophytes on surface No 1.

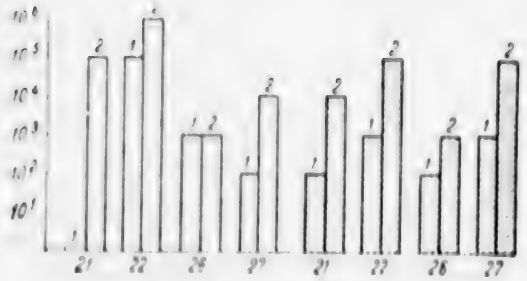

Figure 1.
Microorganisms on integumental tissues of flight group of animals

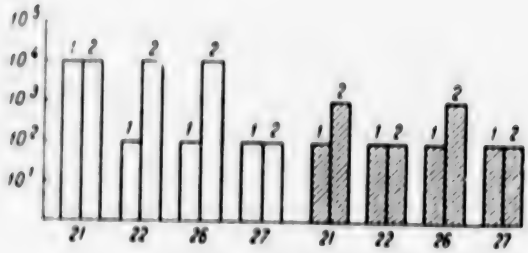

Figure 2.
Microorganisms on integument of animals of control group in synchronous ground-based experiment

Here and in Figure 2: x-axis, numbers of animals examined; y-axis, quantity of microorganisms on sponge; white bars--microorganisms in mouth; striped bars--in fur

1 and 2) microorganism content before and after flight, respectively

Examination of aeroplankton in the Cosmos-1129 mockup (Table 2) revealed that essentially Gram-positive and Cram-negative bacilli were demonstrable on the 1st day of the synchronous experiment, whereas by the end of the experiment (16th and 18th days) epidermal staphylococci began to prevail. In addition to representatives of bacterial flora in the air of the Cosmos-1129 mockup, yeast-like fungi were demonstrable on the 9th day of the synchronous control experiment.

Total number of microorganisms increased after the flight, as compared to background data, on the integument of experimental rats (Cosmos-1129 biosatellite) (Figures 1 and 2). In the flight group of rats these changes were more marked (seen in more animals) than those observed in the control experiment. Definite changes were also recorded in species composition of integumental microflora of animals after the flight. Thus, while we periodically demonstrated pathogenic staphylococci in the mouth before the flight, in samples taken from animals after the biosatellite landed such microorganisms were not found. At the same time, during the flight, there was an increase in number of animals, in the group examined, in whose mouth there were E. coli.

Our findings indicate that the process of operating biosatellites is not associated with adverse changes in microflora of the animals' (rats') environment. This warrants the belief that the set of life-support systems used in these spacecraft, as well as the general hygienic and special disinfection measures performed in the preflight period provide for a normal sanitary-microbiological situation during the experiments.

At the same time, changes were noted in composition of rat automicroflora during the flight, which can be assessed as dysbacteriotic. For this reason, it is necessary to conduct further studies to determine the mechanisms of development of these changes and develop ways and means of preventing them.

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DYNAMICS OF QUANTITATIVE AND QUALITATIVE CHANGES IN CONDITIONALLY PATHOGENIC MICROFLORA OF THE HUMAN INTESTINE DURING LONG-TERM HYPOKINESIA

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 6, Nov-Dec 84 (manuscript received 15 Jul 83) pp 81-83

[Article by N. A. Polikarpov and V. M. Shilov]

[Text] It is known that spaceflight conditions could lead to change in both nonspecific resistance to infection and specific immunological reactivity [10, 11, 15]. They can disrupt relative equilibrium in the composition of the human microbial cenosis [6, 16].

Since conditional enterobacteria play an important part in the etiology of infectious diseases of man [4, 12, 14], it was interesting to investigate the conditionally pathogenic microflora of the human intestine under antiorthostatic [head-down tilt] and long-term hypokinetic conditions.

We are submitting here the results of studies of quantitative and species composition of conditionally pathogenic microflora of the intestine of subjects submitted to antiorthostatic hypokinesia (AOH) for 182 days.

Methods

These studies were conducted on 18 essentially healthy male subjects 36-40 years of age, who had undergone examination by a medical expert commission and were deemed to be clinically healthy.

The subjects were divided into 3 equal groups with regard to health status (6 in each group) in accordance with the nature of preventive agents used.

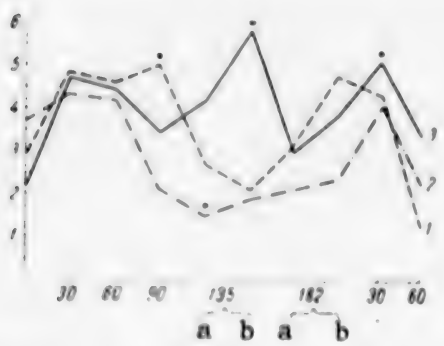
The first group used the full set of preventive measures (regular exercise, electric stimulation of muscles, lower body negative pressure--LBNP--combined with water and salt supplements). The second group made use of a shorter set of preventive agents and methods. The third group of subjects constituted the control (without use of preventive measures, with adherence to a strict regimen of limited movement).

We made an in-depth examination of the subjects on the 50th, 90th, 135th and 182d days of hypokinesia with use of several functional tests (active orthostatic test from seated position, graded physical exercise constituting

300 and 600 kg-m/min). Microbiological samples were collected once a month, as well as twice a day before and after the above-mentioned functional tests. When examining the intestinal microflora, we paid special attention to the quantitative and species composition of conditionally pathogenic microorganisms. Conditionally pathogenic microorganisms were isolated and counted with use of differential diagnostic nutrient media prepared by the method of Bendig and Haenel [18]. We identified the isolated microorganisms by a method developed at the Moscow Scientific Research Institute of Hygiene imeni F. F. Erisman [8]. The obtained results were submitted to statistical processing by a method proposed by I. P. Ashmarin and A. A. Vorob'yev [1].

Results and Discussion

The results of these studies revealed that conditionally pathogenic microorganisms of the Enterobacteriaceae family were isolated from 13 out of the 18 subjects in the background period. In 11 cases, there was an insignificant quantity of conditionally pathogenic microorganisms, and the number of K. pneumoniae and E. aerogenes exceeded normal (6.15±0.02 and 6.43±0.01 log/g, respectively) in only 3 subjects.



Dynamics of quantity of conditionally pathogenic enterobacteria isolated from subjects
X-axis, day of examination;
y-axis, quantity of bacteria per gram feces (in log of absolute numbers)

Ф) background [not in source]
ПР) recovery period "
a) before being "cut down"
b) after " " "
1-3) 1st, 2d and 3d groups
*Statistically reliable differences.

On the 30th day of hypokinesia all three groups of subjects presented a tendency toward increase in number of conditionally pathogenic enterobacteria. However, the most significant increase in their number in the intestine, as compared to background data, was found in the third group of subjects (see Figure).

By the end of the 2d month of observation the quantity of conditionally pathogenic enterobacteria remained on the same level in all groups as on the 30th day of hypokinesia. The species composition of enterobacteria demonstrable at this time also remained virtually unchanged.

On the 90th day of hypokinesia, the 2d and 3d groups of subjects showed a decrease in number of conditionally pathogenic microorganisms. However, on the 135th day, after the functional loads, the 3d group of subjects presented a reliable ($P<0.05$) increase in number of these microorganisms, whereas in the 1st and 2d groups of subjects there was no appreciable change in total number of conditionally pathogenic microorganisms.

On the 182d day, maximum number of conditionally pathogenic enterobacteria in the large intestine was observed in 3 subjects of the 3d group, in whom the quantity of enterobacteria of the genus Citrobacter exceeded normal (6.0 log/g).

At this time, only 1 subject in the 1st group presented an increase in number of bacteria of the genus Citrobacter (6.4±0.03 log/g) to above normal levels. We failed to observe appreciable differences in quantity of conditionally pathogenic enterobacteria in the 2d group of subjects before and after the functional tests on the 182d day.

On the 30th day of the recovery period, all subjects showed significant quantities of conditionally pathogenic enterobacteria, and it is only on the 50th day of the recovery period that we observed normalization of their number and species composition.

Thus, investigation of the microflora of the large intestine revealed that long-term, 182-day AOH was associated with quantitative and qualitative changes in composition of conditionally pathogenic microorganisms in the subjects.

In the background period, in most subjects there was an insignificant number of conditionally pathogenic microorganisms in the large intestine, and it corresponded to normal, from 2.0 to 4.0 log/g feces. However, already by the end of the 1st month of hypokinesia the quantity of conditionally pathogenic microorganisms had increased in most subjects to 5.0-6.0 log/g. In addition to the increase in conditionally pathogenic microorganisms, during hypokinesia we also isolated such normally rare microorganisms in healthy humans as bacteria of the species H. atvei, P. stuartii, as well as P. mirabilis, P. rettgeri, P. vulgaris and P. aeruginosa, the presence of which is indicative of adverse (dysbiotic) changes in the intestinal microflora [6, 7]. The most marked changes in composition of conditionally pathogenic microflora of the intestine were observed in subjects of the 3d (control) group. The results of our studies are consistent with the results of physiological investigations, which are indicative of the most marked deconditioning of subjects in the 3d group [2, 13].

Our findings indicate that use of a set of preventive measures (in particular, exercise), which has a beneficial effect on the general physiological status, apparently is instrumental in preserving antimicrobial resistance on a higher level than in the control group. This resulted in stabilization of quantitative and species composition of conditionally pathogenic microflora of the intestine. This is also confirmed by the results of studies made by other authors, who observed the beneficial effect of exercise on resistance to infection [3, 9, 17]. The works of a number of Soviet and American specialists [5] are also indicative of the importance of preventive measures during long-term spaceflights.

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RAT TISSUE OPIOID PEPTIDE CONTENT DURING LONG-TERM HYPOKINESIA

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 6, Nov-Dec 84 (manuscript received 24 Oct 83) pp 33-85

[Article by R. A. Tigranyan and O. P. Vakulina]

[Text] A conception has been formed to the effect that opioid peptides play an important part in adaptive protective changes under extreme conditions [10, 16]. It was shown that opioids are of substantial significance in controlling a number of physiological functions--respiration, blood pressure, endocrine and digestive system function, body temperature. On the basis of numerous data, it is postulated that there is an extensive antinociceptive system in the animal brain, the principal neurotransmitters and modulators of which are endorphins and enkephalins [2, 6]. When activated under stress, this endogenous analgesic system controls the level of pain sensibility, modulates emotional, behavioral and hemodynamic components of stressor effects [2, 10, 12].

It is known that hypokinesia, which is one of the extreme factors of space-flights, leads to marked changes in neurohumoral regulation of many body functions [5, 9); however, there are no data in the literature concerning the involvement of opiate systems in processes of adaptation to hypokinesia. For this reason, we have studied here the levels of enkephalins and β-endorphins in blood, parts of the brain and adrenals during hypokinesia of different duration (up to 60 days) and in the recovery period after 60-day hypokinesia.

Methods

This work was done with male Wistar rats weighing 200-250 g. Hypokinesia was produced by placing the animals in plastic box-cages [11]. They were tested after 1, 3, 7, 30 and 60 days of hypokinesia, as well as on the 7th and 21st days after 60-day hypokinesia. We analyzed levels of methionine (ME) and leucine (LE) enkephalins, and β-endorphin (BE) in the hypothalamus, mesencephalon, medulla oblongata and hypophysis, as well as ME and LE in the striatum; these parts of the brain were isolated by the method in [17]. We assayed BE of blood plasma and ME of the adrenals. The concentrations of opioid peptides in tissues and blood plasma were determined by the method of radioimmune analysis using the commercial sets of the Immuno Nuclear Corporation (United States). The methods of preparing blood and tissue samples for analysis have been described previously [8]. Statistical reliability of data was assessed according to Student's t test.

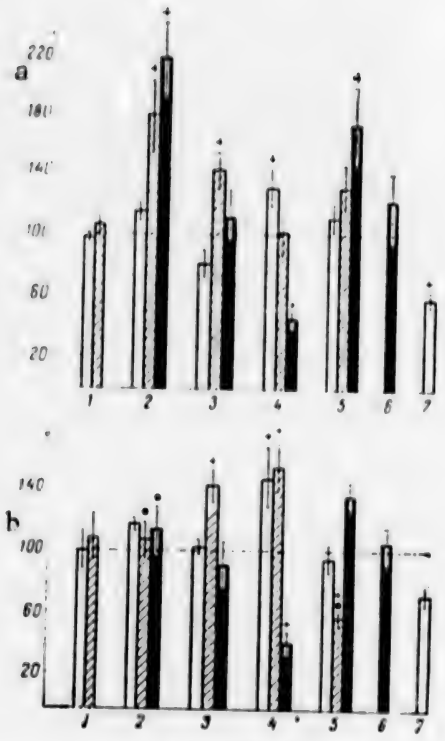

Figure 1.
Opioid peptide content (% of control) with 1-day (a) and 3-day (b) hypokinesia
Here and in Figures 2-4:
1) striatum
2) hypothalamus
3) mesencephalon
4) medulla oblongata
5) hypophysis
6) blood plasma
7) adrenals
White bars--ME, striped--LE, black--BE;
+ -reliable differences from control;
● -reliable differences from preceding test.
Control levels (pmol/mg):
striatum 1.212±0.089 (ME), 0.419±0.046 (LE); hypothalamus 0.716±0.075 (ME), 0.347±0.035 (LE), 0.179±0.020 (BE); midbrain 0.283±0.031 (ME), 0.076±0.007 (LE), 0.014+0.0013 (BE); medulla 0.211±0.026 (ME), 0.101±0.006 (LE), 0.018±0.003 (BE); hypophysis 0.612±0.074 (ME), 0.375±0.045 (LE), 6.50±0.81 (BE); blood (femtomol/mℓ) 110.8±15.0 (BE); adrenals 0.024±0.002 (ME)

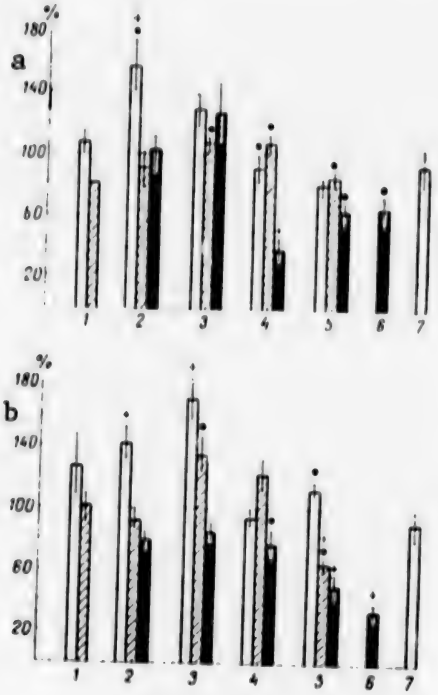

Figure 2.
Opioid peptides (% of control) with 7-day (a) and 30-day (b) hypokinesia

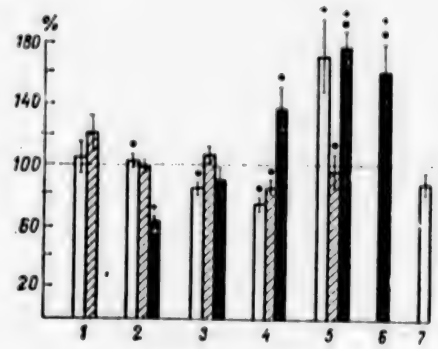

Figure 3.
Opioid peptides (% of control) with 60-day hypokinesia

Results and Discussion

Brief hypokinesia (for 1 day) was associated with increase in BE content of the hypothalamus and hypophysis, LE in the hypothalamus and midbrain and ME in the medulla, as well as decline of BE level in the medulla and ME in the adrenals (Figure 1a). On the 3d day of hypokinesia, the high BE level in the hypophysis, LE and BE in the hypothalamus dropped to control values. There was appreciable decrease in LE concentration in the hypophysis; LE in the mesencephalon and medulla and ME in the medulla exceeded control levels, while BE of the medulla was below the control level (Figure 1b). Restriction of mobility for 7 days elicited a rise in ME level of the hypothalamus (as compared to the control and 3d day of hypokinesia), as well as decrease in concentration of BE in the medulla. BE content of the hypophysis, ME and LE of the medulla and LE of the midbrain decreased, while LE level of the hypophysis rose, in comparison to 3-day hypokinesia (Figure 2a).

It is known that the early stage of hypokinesia elicits a marked stress reaction in animals, which is manifested by greater secretion of ACTH, corticosterone and activation of the adrenosympathetic system [3, 4. 11]. The elevation we demonstrated of BE and LE levels in emotiogenic structures of the brain on the 1st day of hypokinesia is apparently due to development of emotional stress in the rats when placed in the cages. According to the most recent data [13, 14], enkephalins of the adrenals are in the form of chromaffin granules together with epinephrine. Perhaps the decrease in amount of ME-like compounds in the adrenals on the 1st day of hypokinesia is attributable to their cosecretion with epinephrine in blood. This hypothesis is consistent with data to the effect that there is a decline of epinephrine level in the adrenals on the first days of hypokinesia [4].

Keeping the animals in hypokinetic cages for 30 days was associated with significant decrease in LE and BE content of the hypophysis and BE of blood plasma, as compared to control levels, whereas the concentration of ME in the hypothalamus and mesencephalon was greater than the control. ME level in the hypophysis, LE in the midbrain and BE in the medulla oblongata rose, while LE of the hypophysis dropped, as compared to the values for 7-day hypokinesia (Figure 2b). The marked decrease in BE content of the hypophysis and blood plasma is indicative of diminished synthesizing and secreting activity of endorphinergic cells of the hypophysis; we also observed a decrease in concentration of LE in the hypophysis. LE was demonstrated in the neurohypophysis, in nerve endings containing vasopressin [15], and for this reason the changes in secretion of vasopressin and diuresis during hypokinesia [5, 9] can be related to disturbances in the pituitary gland's opiate system. Interestingly, ME level in different parts of the brain showed an opposite change on the 30th day of hypokinesia from those in LE and BE; probably this is attributable to the difference in functional role of these peptides in the body: LE, which has great affinity for delta receptors, determines the emotional state, while ME determines antinociceptive effects [7].

On the 60th day of hypokinesia there was marked increase in concentration of ME and BE in the pituitary and BE in blood plasma, as well as decrease in BE content of the hypothalamus. There was decline of ME level in the hypothalamus,

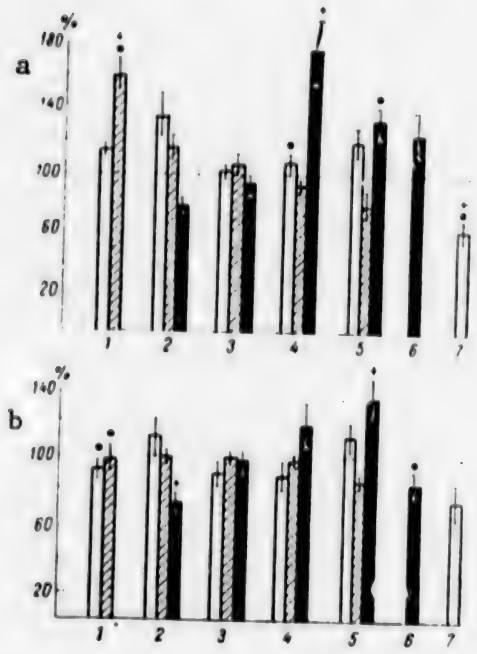

Figure 4.
Opioid peptides (% of control) on 7th (a) and 21st (b) days of recovery period following 60-day hypokinesia

mesencephalon and medulla, increase in LE content of the hypophysis and BE in the hypophysis, medulla and blood plasma, as compared to values found with 30-day hypokinesia (Figure 3). These data are probably indicative of adaptive increase in BE synthesis in the pituitary and/or efflux of BE from the hypothalamus into the hypophysis. The nature of changes in BE content in the hypothalamus throughout the period of hypokinesia (increase on the first days, normalization by the 30th day, decrease on the 60th day) is probably related to the observed fluctuations of synthetic function of hypothalamic neurons under hypokinetic conditions [1].

Returning the rats to a common cage after 60-day isolation elicited a stress reaction: they were very aggressive toward one another, constantly screeched and fought.

We observed increase in LE concentration in the striatum and BE in the medulla and decrease in ME content of the adrenals on the 7th day after 60-day hypokinesia, as compared to intact animals. LE level in the striatum and ME in the medulla were higher, while pituitary BE was lower than in animals submitted to 60-day hypokinesia (Figure 4a).

On the 21st day of the recovery period, the concentration of opioids in the tissues tested did not essentially differ from intact animals; the only exceptions were the high BE content of the hypophysis and low BE level in the hypothalamus (Figure 4b).

Thus, the first days of restricted motor activity and early stage of recovery following prolonged hypokinesia elicited stress reactions in animals, which were associated with marked changes in the opiate systems of the brain and adrenals. Prolonged isolation and hypokinesia have the strongest effect on endorphinergic neurons of the hypothalamohypophyseal axis.

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EFFECT OF LONG-TERM REPEATED EXPOSURE TO HIGH-INTENSITY STATIONARY MAGNETIC FIELD ON ADRENOMEDULLARY ACTIVITY

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 6, Nov-Dec 84 (manuscript received 19 Apr 83) pp 86-87

[Article by L. V. Kokoreva]

[Text] In the last few decades there has been noticeable expansion of the area of application of magnetic units, which has led to increase in number of workers who are regularly exposed to stationary magnetic fields (SMF) of medium and even high intensity [2]. For this reason, it is necessary to investigate the distinctions of reactions, primarily of the body's adaptive systems, to regular exposure to SMF. There are indications in the literature of change in activity of the adrenosympathetic system and some morphological changes in the adrenal medulla under the effect of SMF [3-5, 10-12].

Our objective here was to investigate the dynamics of changes in catecholamine (CA) content of blood plasma and adrenal tissue during long-term regular exposure to SMF with induction of 1.6 T.

Methods

The studies were pursued on 94 male mongrel rats (49 animals made up the experimental group and 45, the control). The experimental group of rats was exposed to whole-body vertical magnetic field with induction of 1.6 T for 3 h/day. An SP-57A electromagnet with polar tips in the form of a circle, with a 450-mm radius and air space between them 100 mm in size, was used to generate the magnetic field. The generated magnetic field was strictly stationary and homogeneous over a radius of 380 mm, and induction decreased to 1.3T toward the edge of the pole tip. The rats were put in the gap of the electromagnet in plexiglas cages in the shape of a sector of a circle. Control rats were kept in the same room under analogous conditions, in the phantom of polar tips made of duralumin. All of the animals were given pelleted feed, grain, cottage cheese, carrots and water ad lib. The experimental group of rats was decapitated right after discontinuing 1-, 5-, 12- and 30-fold 3-h exposure to SMF. Control animals were decapitated at the same times. Epinephrine (E) and norepinephrine (NE) content of the adrenals was determined fluorimetrically according to E. Sh. Matlina and T. B. Rakhmanova (1967), and blood E according to E. Sh. Matlina [8].

Results and Discussion

Repeated daily exposure to SMF with induction of 1.6 T for 3 h/day for 1 month had no noticeable effect on the animals' general condition or weight, or on absolute and relative weight of the adrenals (Table 1).

Table 1. Effect of daily 3-h exposure to 1.6 T SMF on weight of rat body and adrenals

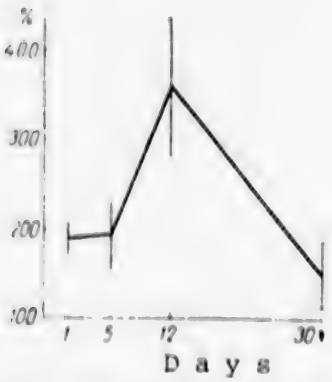
Number of exposures to SMF	Body weight, g		Weight of adrenals			
			absolute, mg		relative, mg/100 g body wt.	
	control	exper.	control	exper.	control	exper.
1	211,0±6,98 (n=10)	200,3±4,70 (n=15)	21,48±1,60 (n=10)	21,08±1,25 (n=10)	7,95±0,56 (n=10)	7,78±0,41 (n=10)
5	227,0±7,61 (n=10)	220,7±4,05 (n=15)	20,58±1,73 (n=14)	21,14±1,79 (n=14)	9,18±0,45 (n=14)	9,12±0,49 (n=14)
12	263,9±9,23 (n=9)	249,3±3,87 (n=15)	21,07±0,86 (n=10)	20,44±1,46 (n=10)	6,82±0,49 (n=10)	7,02±0,29 (n=10)
30	312,0±12,07 (n=10)	287,7±5,83 (n=15)	22,65±0,44 (n=11)	23,0±1,30 (n=15)	7,87±0,14 (n=15)	7,37±0,40 (n=15)

Note: Number of animals is given in parentheses.

Table 2. Effect of daily 3-h exposure to 1.6 T SMF on adrenal CA content

Number of exposures	Number of animals	CA content, mg/g tissue		
		E	NE	E/NE
1	10	707,2±57,50	237,97±22,50	3,62±0,[illegible]
5	14	723,18±74,70	263,43±27,71	3,32±0,[illegible]
12	10	780,0±48,03	233,9±38,20	5,27±1,[illegible]
30	15	709,5±46,30	235,85±29,51	3,55±0,[illegible]
Control	34	709,9±23,12	216,13±14,90	4,23±0,[illegible]

Testing of E content of plasma in the same rats revealed distinct signs of adrenomedullary system reaction to the magnetic field. After the first 3-h exposure to SMF with induction of 1.6 T, hormone content in blood increased by about 2 times (9.08±2.05 and 4.8±0.95 ng/mℓ in experimental and control groups of animals, respectively). A peak reaction was observed after 12-fold exposure (see Figure). By the 30th exposure to SMF, E content was virtually restored to base values. The increase in blood E concentration was not associated with any significant changes in adrenal CA content (Table 2). At all tested times, E and NE content of adrenal tissue in the experimental group of animals did not differ from the control, and this can



Epinephrine concentration in rat blood during 30-fold exposure to 1.6 T SMF
X-axis, days of exposure to SMF: y-axis, content (% of control); arrowhead shows end of exposure.

apparently be attributed to activation of synthetic processes compensating for CA secretion in blood [6].

In assessing the reaction of the adrenal medulla to SMF, it can be noted that it was similar to the manifestation of systemic, nonspecific defense reaction that usually takes place with increase in activity of the adrenosympathetic system. The effect of SMF with induction of 1.6 T is comparable in intensity to the effect of mild stimuli, such as non-tiring muscular activity, moderate hypoglycemia, loss of blood and others, which elicit 2-3-fold elevation of blood E concentration, as compared to normal [7, 15]. With strong stressors, this figure could increase 10-20-fold [7, 15].

We cannot fail to observe that high blood E concentration persisted for a rather long time with repeated daily exposure to SMF. This is apparently a typical reaction by the adrenosympathetic system to various stress-producing agents [1, 9, 13, 14], including SMF.

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EFFECT OF STATIONARY MAGNETIC FIELD ON BLEEDING TIME

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 6, Nov-Dec 84 (manuscript received 3 May 83) pp 87-89

[Article by E. Gorchinskaya (Polish People's Republic)]

[Text] The geomagnetic field, being one of the basic physical environmental factors, determines the course and activity of physiological processes in man and animals [1, 6, 14, 15]. Modern industry generates zones of increased magnetic field intensity, in which it may be necessary for man to spend some time.

The results of numerous experiments have proven that prolonged exposure to an exogenous magnetic field elicits hemostatic disturbances [2, 3, 11].

We report here on a study of the effect of a stationary magnetic field on bleeding time in guinea pigs, and we also assessed the role of biological rhythms.

Methods

The study was conducted on 60 guinea pigs weighing 480-550 g. The animals were divided into 6 groups (10 animals in each group): the first group consisted of control animals that were not exposed to the magnetic field. The animals in the other groups were exposed to a magnetic field for 1 h/day for 6 weeks: with intensity of 0.005 T (2d group), 0.05 T (3d), 0.1 T (4th), 0.2 T (5th), 0.3 T (6th). We examined recovery of bleeding time 2 weeks after exposure to the magnetic field (0.1 T and 0.2 T).

Field intensity was measured with a TA-26 teslometer based on the Hall effect. The animals were placed between the poles of a magnet, and the distance between the poles was 20 cm.

Bleeding time and thrombocyte count in blood vessels were determined by the method of Duke [9]. We measured the time from the moment a wound was produced on the earlobe to the moment that bleeding stopped. Blood was removed every 10 s using pieces of blotting paper.

Table 1. Effect of stationary magnetic fields of different intensity on bleeding time (M±SD)

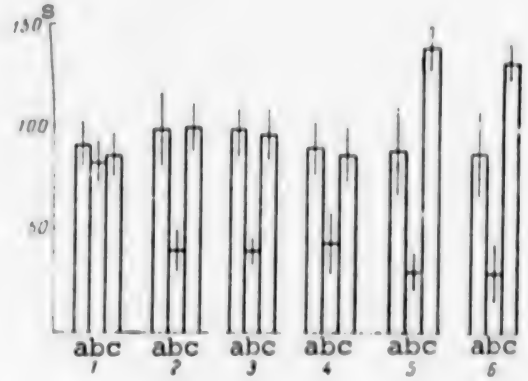
Animal group	Magnetic field intensity, T	Before exposure to magnetic field	Duration of exposure to magnetic field, days					
			4	11	18	25	32	40
1	Control group	91.6±10.3	85,6±10,9	85,0±11,39	82,7±9,35	82,5±11,0	85.3±12.1	86.2±9.7
2	0.005	99.3±17.5	74,0±14,87	49,7±15,3*	39,6±9,2*	64,8±10,8*	81.0±13.4	99.8±11.6*
3	0.05	99.1±13.46	72,8±14,9	54,4±10,52*	39,5±6,05*	62,0±13,37*	82.2±11.96	96.3±12.02
4	0.1	89.4±12.53	75,9±9,07	53,8±11,42*	43,4±14,62*	32,7±14,78*	66.9±8.11*	89.3±13.13
5	0.2	88.5±12.91	61,2±14,43*	43,0±12,0*	29,6±8,14*	66,3±8,51*	108.1±14.44*	138.5±10.43*
6	0.3	86.6±20.14	41,4±12,85*	30,6±7,94*	28,7±10,39*	60,9±16,38*	102.1±9.85*	131.5±8.01*

*p<0.02

Results and Discussion

The results of the study enabled us to define the range of changes under the effect of rhythmic exposure to magnetic fields with intensity of 0.005-0.3 T on experimental animals.

As can be seen in Tables 1 and 2, bleeding time on the 18th day of exposure to the magnetic field decreased reliably (P<0.001) from 86.6±20.14-99.1±13.46 s to 28.7±10.93-43.4±14.62 s. In the control group, bleeding time was 82.7±9.35.



Bleeding time in guinea pigs under the effect of 0.005-0.3 T magnetic fields
X-axis, animal groups; y-axis, bleeding time (in seconds)
a) before exposure to magnetic field
b,c) after 18 and 40 days of exposure, respectively

On the 40th day of exposure to the magnetic field, bleeding time was in the range of 86.3±13.13-138.5±10.43 s (86.2±9.7 s in the control group).

The extent of change depended on intensity of the magnetic field. We observed recovery of bleeding time to base values 2 weeks after exposure to the magnetic field (see Figure). In the 5th group of animals it constituted 91.6±14.56 s and in the 6th, 86.0±15.52 s.

Bleeding time is an indicator of hemostatic function of thrombocytes and blood vessels. The effect of magnetic fields on animals depends on field intensity and exposure time.

Table 2. Bleeding time in guinea pigs exposed to magnetic fields with intensity of 0.2 and 0.3 T 2 weeks after termination of exposure

Intensity, T	Base values	After 40-day exposure to magnetic field	On 14th day after 40-d exposure
0.2	88.5±12.91	138.5±10.43*	91.6±14.56
0.3	86.6±20.14	131.5±8.01*	86.0±15.52

*P<0.01

It can be assumed that the change in bleeding time under the effect of magnetic fields is due to impaired function of thrombocytes, as well as increased concentration of catecholamines in blood. The results of this study indicate that a magnetic field is one of the potent stressors that elicit the same reactions as heat, emotions and a physical load [10, 12, 13]. Magnetic fields probably alter the course of biochemical reactions, which leads to thrombocyte aggregation.

The decline of mitotic processes in bone marrow [4, 5, 7, 8] under the effect of magnetic fields is perhaps the cuase of thrombocytopenia and increased bleeding time.

The submitted experimental results indicate that an intensity of 0.005 T (500 s) of a magnetic field may be the cause of certain disturbances in the body.

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UDC: 613.693(049.32)

REVIEW OF U.S. MANUAL OF CLINICAL AVIATION MEDICINE

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 6, Nov-Dec 84 (signed to press 18 Oct 84) pp 89-92

[Review by A. A. Gyurdzhian and V. F. Tokarev of book, "Clinical Aviation Medicine," by R. B. Rayman, New York, Vantage Press, 1982, 245 pages]

[Text] The book by R. Rayman, Colonel in the Medical Corps of the U.S. Air Force, is of considerable scientific and clinical interest to aviation physicians. The vast majority manuals of aviation medicine shed light in essence on questions of physiology, hygiene and psychology, life-support systems and flight safety. Clinical aspects, however, which are so important to the work of the aviation physician, are usually not sufficiently covered in the literature.

This book describes the most frequent diseases of flight personnel that the aviation physician encounters; it discusses the effect of these diseases on flight work and the physician's tactics with regard to treatment and permission to fly in the light of the latest medical advances. Data are submitted on diseases specific to flight personnel and course of different diseases in aviators as related to the distinctions of their work. There is a special place for questions of effects of different drugs and therapeutic methods on flight work. Appropriate recommendations are offered in each case.

In addition to the author's foreword, the book has an introduction, 10 chapters dealing with different clinical disciplines, a bibliography for each chapter and a subject index.

The introduction gives a brief history of clinical aviation medicine, its current status and basic tendencies of development.

In 1917, the first U. S. laboratory of aviation medicine was opened in Mineola (Long Island), which began to elaborate medical standards for flight personnel, investigate the human factor as the cause of loss of aircraft during World War I. While before that time, more flight personnel perished from flaws in medical screening and lack of medical standards than from the enemy's fire, the situation began to improve thereafter. However, the question of medical standards requires constant attention and refinement. It has undergone a long road of evolution, and is still far from being fully resolved.

Historically, the main line of development of medical standards in the United States consisted of turning from stricter health requirements for flight personnel to considerable liberalization at the present time. Such a tendency will probably prevail in the future as well. The author gathered considerable statistical material on U. S. aviation (for a 9-year period), which indicated that flight accidents related to some extent or other to deviations in health status of flight personnel constitute a small share among causes of flight accidents. The book describes well the tasks of aviation physicians to safeguard the health of flight personnel, assure flight safety and improve the efficiency of performance of their professional duties by flight personnel.

The author performed a rather difficult task, having demonstrated the specifics of morbidity, course of diseases and treatment of flight personnel.

One of the chapters deals with internal diseases. It is the longest (70 pages). Diseases of internal organs are the main ones among causes of partial and complete pilot disqualification. Essential hypertension and peptic ulcer, diabetes, diseases of the joints and gastrointestinal disturbances lead the long list of flight personnel diseases.

As we have already mentioned, essential hypertension is in first place. For U. S. flight personnel, maximum blood pressure is considered to be 140/90 mm Hg. The sympatomatology and diagnosis of impaired vascular tonus of flight personnel, as well as tactics of the aviation physician, are described. Then there is discussion of incidence of varicose veins and thrombophlebitis, numerous types of arthritis and spondylitis, disturbances of fluid-electrolyte metabolism, systemic lupus erythematosus, peptic ulcer with localization of ulcers in the stomach and duodenum among flight personnel. The author devotes special attention to the tactics of the aviation physician with regard to flight personnel with bleeding ulcers. The fact of the matter is that R. Rayman has authored an extensive investigation of this problem, the results of which were published in 1978 in the American journal, AVIATION SPACE AND ENVIRONMENTAL MEDICINE. There too is a description of such diseases of flight personnel as diaphragmatic hernia and esophagitis, regional inflammation of the small intestine and ulcerative colitis, intestinal diverticulae, cholelithiasis, cholecystitis and pancreatitis, as well as such an infrequent disease under normal hygienic conditions as pilonidal sinus, which becomes widespread in wartime and is manifested by inflammation around the hair bulbs of the sacrococcygeal region. Patients have to spend 5 to 50 days in the hospitals, while recurrences are encountered in 10-30% of the cases.

Normal external respiration and gas exchange are important to the activities of flight personnel. This factor explains the large amount of attention that the author gives to functional lung tests and evaluation of their results, as well as to discussion of spontaneous pneumothorax, air spaces between the visceral pleural and lung tissue, bronchial asthma, syndrome of chronic constriction of airways with development of emphysema, sarcoidosis of lung tissue and tuberculosis. Special mention is made of coccidioidomycosis and histoplasmosis, which are typical of the southern states, caused by inhalation with dust of special fungi, which lead to specific changes in lung tissue. The history of medicine shows that regional diseases (previously inherent only

in specific localities) are being increasingly distributed over the entire globe.

There is rather comprehensive description of aviation medical aspects of different forms of anemia (pernicious anemia, hereditary spherocytosis). In particular, it was shown that there has been a significant decline of human tolerance to high altitude in the presence of sickle-cell anemia, which is inherent in residents of the African continent.

The same section discusses problems related to polycythemia, lymphatic tissue tumor (Hodgkin's disease), glucose-6-phosphate dehydrogenase deficiency in representatives of different peoples of Asia and Africa, different forms of thyroid dysfunction (Graves' disease, hypothyroidism, multiple nodular thyroid tumor), diabetes mellitus and hypoglycemia, pyelonephritis and glomerulonephritis. There is a special section in this chapter dealing with alcoholism. In 1963, in 43% of the accidents, at least 15 mg% blood alcohol had been found in the flight personnel. The situation improved somewhat thereafter, since a federal law was enacted (1970), according to which at least 8 h must have elapsed after intake of alcohol before flying. However, in 1969-1975, pilot alcohol consumption was recognized as one of the causes of 297 flight incidents, 258 of which were accidents.

Numerous studies have been pursued demonstrating that even infinitesimal amounts of alcohol worsen pilot performance on a simulator and in tracking experiments (increase in number of errors, poorer hearing, impaired myoneural coordination, change in nystagmic reaction, slower reactions and decision-making time). But, perhaps what is particularly important is that alcohol accentuates the stress reaction and lowers tolerance to altitude.

The aviation physician must bear in mind at least three aspects of alcohol effects: acute reaction, chronic sequelae and subclinical forms. While the matter is relatively clear with respect to the first two aspects, since they are associated with distinct symptoms that are known to everyone, the third aspect requires special attention. Unfortunately, there are still no convential medical tactics concerning pilots who consume alcohol, nor is there a distinct boundary between safe and dangerous alcohol intake.

Views concerning the possibility of rehabilitation of alcoholics are particularly contradictory, and this is related to questions of disqualification or permission to fly. The most recent data indicate, in the opinion of R. Rayman, that one should be more optimistic about the possibilities of modern methods of rehabilitating flight personnel suffering from alcoholism and their retention in flight work.

The short third chapter deals with orthopedics and traumatism. Orthopedic pathology (including diseases of the spine) constitutes 20% of all restrictions on pilot fitness according to medical indications. In half the cases, this pathology is due to the sequelae of sustained trauma.

One of the most frequent complaints of flight personnel is of pain in the lower back. In most cases, such pain is temporary and is due to spasm of lumbosacral muscles. However, the cause of the pain could also be more serious.

In particular, there can be changes in intervertebral cartilages causing impingement of intervertebral pulp and nerve radices. In 50% of the cases, there is trauma and strain on the spinal column in the history of such individuals. In addition, there is discussion of such nosological forms as spondylolysis (in 85% of the cases arch defect of the 5th lumbar vertebra and in 15% of the 4th lumbar vertebra). Flight personnel who have ejected from aircraft require special attention and long-term observation for detection of compression fractures of vertebrae and their sequelae.

Neurological aspects are covered in the fourth chapter. In first place are diseases manifested by headache. Various types of migraine are described. In most such diseases, there are ophthalmological and neurological dysfunctions that require removal from flying. In the case of headache due to muscular spasm in the head and neck region, pilots are not grounded if it is not too frequent. The numerous consequences of head trauma, in particular concussion and contusion of the brain, are very important issues to aviation and medical certification of pilots. Posttraumatic and postcontusion syndromes are described. Here, posttraumatic epilepsy and the role of electroencephalography in diagnosing it occupy a special place. Various types of syncope, their differential diagnosis and expert evaluation are well covered. Among the described mechanisms of syncopes, the following draw particular attention: carotid sinus syndrome due to high sensitivity of the sinus and corresponding reflex when there is pressure on it by poorly fitted gear; orthostatic hypotension; closure of rima vocalis with exposure to accelerations, which creates conditions resembling Valsalva's maneuver. Appropriate training of flight personnel reliably prevents development of the last mentioned pathological mechanism.

In this chapter, there is also proper coverage of multiple sclerosis, idiopathic epilepsy and the significance of encephalography for expert medical certification of flight personnel.

Questions of aviation ophthalmology and otorhinolaryngology are discussed rather comprehensively and well in the fifth and sixth chapters. Sections dealing with use of contact lenses by flight personnel, mechanisms and differential diagnosis of various causes of vertigo experienced by pilots in flight are of great interest.

The seventh chapter is the second longest (after the one dealing with internal medicine), and it deals with cardiology. The reason for this size of the chapter is both the leading place of cardiovascular pathology among diseases in modern society and the extremely important significance of correct diagnosis and medical expertise for flight personnel with cardiovascular pathology to assure flight safety. Problems of cardiology as a whole require much attention on the part of specialists in clinical aviation medicine.

The main section in this chapter is a description of different deviations of electrocardiograms (ECG) and their diagnostic significance. On the basis of vast material referable to the U. S. Air Force (more than 120,000 ECG's), variants of normal tracings and the main types of deviations have been identified. We were impressed by investigation of changes in the S-T segment and their relevance to diagnosing ischemic heart disease.

There is then discussion of the main types of valvular pathology, significance of congenital heart disease, angina pectoris, myocardial infarction, rheumatic fever, infectious endocarditis, pericarditis and myocarditis, coronary vessel surgery and syndrome of mitral valve prolapse.

The eighth chapter is concerned with urological pathology; there is discussion of such diseases as urolithiasis, prostatitis, varcocele, hydrocele and spermatocele, as well as congenital defects of the kidneys. In a special section of this chapter important recommendations are offered on examining flight personnel with hematuria and proteinuria without other clinical manifestations.

The short ninth chapter deals with dermatology. In this chapter there is description of the significance to aviation of only a few skin diseases; the tactics of an aviation physician for treating them and offering an expert evaluation are described. For example, pilots must be grounded while under antihistamine treatment for urticaria; one often has to resort to disqualification of flight personnel with a protracted course of lichen planus.

Questions of aviation psychiatry are discussed in the tenth chapter. Of course, mental illness is infrequent in the pilot environment because of the thorough medical screening of flight personnel, their living and working conditions in close interaction of group members. In spite of the absence of a conventional classification of mental disturbances related to aviation, the author porposes the following classification: psychoneurotic disturbances, psychotic deviations, temperament and behavior deviations (personality deviations), psychosomatic disturbances. The first group (psychoneurotic disturbances) generally consists of cases when the nervous system cannot cope with the work and everyday load, which most often leads to anxiety, nervousness, poor wellbeing or the depression syndrome. With a change in conditions, the health status of some individuals can revert to normal. In cases where it is necessary to administer frequent and long-term courses of therapy, or if the psychoneurotic disturbances present a threat to flight safety, the decision is made to disqualify such an individual.

The situation is more serious with regard to psychotic deviations. This usually refers to manifestation of classical mental diseases, most often schizophrenia. Since it is difficult, as the author believes, to prognosticate recurrences and inadequate patient behavior, while it is impossible to combine treatment with flight work, such patients are usually grounded. So-called exogenous psychosis (as a result of febrile and other diseases), which goes away after a somatic cure, is an exception.

Personality deviations (temperament and behavior deviations) are usually subject to influence and training on the part of superiors. There are often instances of simulation by flight personnel. In any case, the aviation physician must be rather restrained in settling the question of disqualifying such individuals, bearing in mind that each pilot disqualification costs the government an average of $350,000.

The medical tactics and treatment of psychosomatic disturbances must be the same as for the corresponding somatic diseases. The aviation physician must take into greater consideration the neuropsychic aspects that provoke this disease and try to improve them.

Finally, we must dwell on two other forms of disturbances: fear of flying and the "separation" phenomenon. Fear of flying may be due to a prior experience (in particular, a flight incident). In this case, appropriate training can overcome fear in 47-77% of the individuals. If fear of flying is based on a phobic neurosis, the probability of continuing with flight work is doubtful. The phobic nature of disturbances is determined according to a number of signs (for example, fear of flying aboard an aircraft assigned a certain number, etc.).

Manifestations of the "separation" phenomenon have been repeatedly described in cases of high-altitude solo flights. They are encountered more often than is usually believed. In most cases, this is a normal reaction to monitonous conditions, the sleepiness and fatigue they induce. But sometimes the mental distinctions of the pilot are involved (anxiety neurosis). During pilot education and training, it is important to stress attention on the fact that pilots must not lose vigilance or have diminished work capacity under such conditions.

The last, eleventh chapter deals with oncology. Current advances in the treatment of malignant tumors are illustrated by the author with the fact that in 1974 alone, 246 pilots were returned to flight work in the U. S. Air Force, who had had malignant neoplasms. The most frequent localization of cancer is the skin, followed by the lungs, rectum, other digestive organs and the prostate. There is separate description of symptomatology, treatment, prognosis and aviation medical tactics in cases of malignant melanoma, basal-cell and squamous-cell carcinoma, testicular and thyroid cancer.

Unfortunately, not all issues important to clinical aviation medicine were covered fully enough in the book. In particular, we would have liked to see a description of the current status of efficacy of medical screening of secondary school graduates for aviation and related drop-out of students during the first years of training. In our opinion, not enough was also said about new methods of examination, tests and criteria of screening, their comparative value and differential diagnostic significance.

UDC: 615.2/.3.035.1/.2:613.693](035)(049.32)

REVIEW OF U.S. GUIDE ON MEDICATION AND FLYING

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 6, Nov-Dec 84 (signed to press 18 Oct 84) pp 92-93

[Review by E. M. Panova and V. F. Tokarev of book, "Medication and Flying. A Pilot's Guide," by S. Mohler, Boston Publishing Company, Boston, MA, United States, 1982, 214 pages]

[Text] This guide is one of the first on pharmacotherapy for flight personnel and aviation physicians.

The name of Dr S. Mohler, a pilot-physician and formerly one of the administrators of the medical service and aviation medicine of the U. S. civil aviation, who has authored a number of manuals on aviation medicine for flight personnel, is well-known to Soviet specialists.

His book is a sort of guide with recommendations on questions of safety of intake of various drugs by pilots. It answers the following groups of questions:

> What drugs can a pilot take before flights?
> How much time after intake of a specific medication must elapse before a pilot can be allowed to fly?
> Can the altitude of a flight influence the effect of a drug?

The book contains basic information about more than 200 drugs that are either dispensed by prescription or without it.

The agents are classified according to their effects on inflight performance.

The book lists agents (giving generic and patented names), describes the marked side-effects of each of them, lists indications for intake of agents and time required for their elimination.

Medication, particularly of the type sold over the counter without a medical prescription, has become a common phenomenon in our life. Most people have taken at some time or other drugs against colds, allergies, to relieve gastric discomfort, as well as medication prescribed by a physician without thinking too much about their possible side-effects.

The book consists of an introduction, 10 chapters, 2 appendixes and an index. It has information about the most commonly used drugs in the medical practice of aviation physicians.

Data are submitted about the chemistry of the products, their physicochemical properties, pharmacodynamics, indications and contraindications, dosage and possible side-effects.

Chapter 1 has essentially general information about medication, usage (with and without a physician's prescription), unusual reactions to intake of some drugs, with examples of their adverse effects on pilots.

Chapter 2 discusses the most widespread medication--alcohol, categories of alcoholic beverages, their consumption and effect on man, blood alcohol levels and, finally, effect of alcohol on pilot performance. The legal bases regulating intake of alcoholic beverages by pilots are given. For example, objective studies during flights revealed that even an 0.040% blood alcohol content has a marked adverse effect on a pilot's professional performance.

Chapter 3 has data about the effect of nicotine on pilots. Drugs that have been banned and removed from the list are discussed in Chapter 4.

Definitions of special medical and pharmaceutical terms are provided as they appear in the text in order to help a pilot comprehend more fully the nature and effects of the drugs mentioned.

The products are listed in the chapters in alphabetical order by their generic names. Chapters 5-10 deal with products referable to the following categories:

> Intake of the product usually allows for performance of inflight job (Chapter 5).
>
> Performance of professional duties and flying are possible with the permission of the aviation physician (Chapter 6).
>
> Performance of inflight duties may be allowed by the Civil Aviation Federal Administration in specific cases (Chapter 7).
>
> Performance of inflight duties is forbidden until the product in question is entirely eliminated from the body. In each individual case, consultation with an aviation medicine expert is recommended; one must also check the half-life of a specific product and time required for it to be excreted (Chapter 8).
>
> Illness at the treatment stage precludes performance of inflight duties (Chapter 9).
>
> The adverse effect of the drug precludes performance of inflight duties (Chapter 10).

Appendix 1 consists of five lists of drugs (1--narcotics, 2--agents that have a predominant effect on the central nervous system, 3--drugs containing a

limited amount of specific narcotics, 4--agents with less narcotic action that on the first three lists (such as barbital, phenobarbital, methylphenobarbital and others), 5--agents containing limited amounts of specific narcotics (mainly with antitussive and antidiarrheal action).

Appendix 2 contains a list of 200 drugs that are the most frequently used in ambulatory practice, with their patented and generic names, as well as the recorded number of cases of using the drug.

The book concludes with a brief bibliography and extensive subject index, which permits finding (chapter and page) the description of a product by its main name or synonyms, and its place in one of the six categories characterizing the effect of the product on flight performance.

In evaluating this book, it must be acknowledged that the data it contains about drugs and their effects on flight work are of definite interest.

ANNIVERSARIES

UDC: 613.693:92 Sergeyev

ALEKSANDR ALEKSANDROVICH SERGEYEV (ON HIS 90TH BIRTHDAY)

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 6, Nov-Dec 84 (signed to press 18 Oct 84) pp 93-94

[Article by editorial board]

[Text] Professor Aleksandr Aleksandrovich Sergeyev, doctor of medical sciences, retired colonel of the medical service and one of the founders of Soviet aviation medicine celebrated his 90th birthday on 5 August 1984.

A. A. Sergeyev was a participant in World War I, the civil and Great Patriotic wars. While still a student at the Military Medical Academy, he rendered surgical care to the wounded on the fronts of World War I, and he worked as a surgeon during the entire civil war (by that time Aleksandr Aleksandrovich had already graduated from the Academy). During the Great Patriotic War, A. A. Sergeyev was chief of the surgical department of the Naval Hospital in blockaded Leningrad. In 1923, A. A. Sergeyev was assigned to perform his military service as physician in a school for aircraft observers. At the same time, he attended the full course of aircraft observer training and received special training in aviation medicine in the laboratory of N. M. Dobrotvorskiy. While working in the laboratory, Aleksandr Aleksandrovich realized how little physiology of flight work had been studied, became aware of its practical importance and became interested in this problem. The range of questions that attracted A. A. Sergeyev is quite broad. He has published works dealing with physical training of flight personnel, use of oxygen gear at high altitudes, possibilities for evacuating the sick and wounded in aircraft. Problems of hypoxia, function of the vestibular analyzer during flights, significance of oxygen to the work of pilots, acoustical trauma and traumatism among flight personnel, pressure chamber conditioning, altitude decompression sickness and many others occupy a large place in his work. A. A. Sergeyev devoted particular attention to the problem of accelerations and their effect on pilots.

In 1933, A. A. Sergeyev was asked to head a group of scientists (subsequently, Academician L. A. Orbeli replaced him in this capacity) to develop a plan for a flight into the stratosphere in a balloon. The experimental work was done in the department of physiology of the Military Medical Academy. After scientific validation of training programs, oxygen supply, removal of carbon dioxide and some other issues, the immediate participants in this flight

underwent training. As we know, the flight of the Osoviakhim stratostat did take place, and aeronauts P. D. Fedoseyenko, I. D. Usyskin and A. B. Vasenko ascended to 22,000 m, which no one in the world had ever reached before.

Starting in 1926, along with his scientific research work, A. A. Sergeyev was very active in pedagogic work. He became assistant in the department of physiology of the Naval Medical Academy in 1940 and worked there up to 1956, heading the department of aviation medicine for the last few years. The results of the many years of research (more than 30 years) done by A. A. Sergeyev were written up in two monographs: "Effect of Accelerations on Pilots" (Voyenizdat, 1957) and "Physiological Mechanisms of Effects of Accelerations" (Izdatel'stvo USSR Academy of Sciences, 1969). A. A. Sergeyev retired in 1956, and worked as scientific secretary at the Institute of Physiology, USSR Academy of Sciences, from 1957 to 1973. During this period he devoted much time to the study of the history of development of physiology and aviation medicine, as well as to bibliographic work. In 1962, the monograph by A. A. Sergeyev was published, "Essays on the History of Aviation Medicine," which was submitted in defense of the degree of doctor of medical sciences (1963). In 1969, 1974, 1978 and 1980, 4 volumes were published of bibliographies of Russian literature dealing with aviation, space, high-altitude biology and medicine, in the compilation of which A. A. Sergeyev was a participant.

A. A. Sergeyev is an honorary member of the All-Russian Physiological Society imeni I. P. Pavlov, he has been a participant in the scientific lectures dedicated to K. E. Tsiolkovskiy, Yu. A. Gagarin and other scientific forums.

The Soviet government has appreciated highly the sociopolitical and scientific endeavors of A. A. Sergeyev, having bestowed upon him the Order of Lenin, two Orders of the Red Banner, two Orders of the Red Star and many medals.

The scientific community, specialists in aviation and space medicine, the editorial board of the journal, KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA, his friends, comrades, disciples and followers congratulate Aleksandr Aleksandrovich on his glorious birthday and wish him good health and further creative achievements in his scientific endeavors for the good of our great homeland.

SYNOPSES OF ARTICLES FILED WITH THE ALL-UNION SCIENTIFIC RESEARCH INSTITUTE OF MEDICAL AND MEDICOTECHNICAL INFORMATION AND ALL-UNION INSTITUTE OF SCIENTIFIC AND TECHNICAL INFORMATION

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 6, Nov-Dec 84 (signed to press 18 Oct 84) pp 95-96

UDC: 612.67:613.693:616-021

BIOLOGICAL AGE, MORBIDITY AND LONGEVITY OF FLIGHT PERSONNEL

[Synopsis of article by V. V. Vlasov]

[Text] Aging of the body is characterized by the increased probability of death and loss of work capacity, which are manifested as a result of development of diseases and their complications. On the basis of data referable to in-hospital examinations of pilots and navigators (731 people checked twice at intervals of 3-5 years and 201, once), an effort was made to analyze the link between flight personnel longevity and correlates of biological age (BA) and signs of diseases or premorbid states (early stage of disease--ESD). The subjects were divided into six groups according to dynamics of their health status. To assess age-related changes, data from the first examination of individuals with stable health status were used, since some of these individuals could have been in an ESD state at the second examination. To evaluate signs of ESD, we used data obtained from the first examination of individuals with worsening of health status at the second one. It was found that age-related changes were less marked in the group of healthy individuals with stable health status, and they were considerably more marked if special steps were not taken to single out subjects with developing diseases. A formula was developed for assessment of BA. For individuals rated younger than their age, the probability of retaining good health for 5 years was high. Since the applicability of such formulas was limited, we used the method of building a "profile" of parameters. It was shown that individuals with ESD or clinical stage of a chronic disease, as well as those deemed unfit for flight work at an early time, had a greater BA. Selection of parameters according to signs of relative stability, coincidence of age-related and morbid changes and suitability for assessing both healthy and sick individuals is of substantial significance to fruitful utilization of the BA conception. 1 table, 2 illustrations, 16 references.

UDC: 612.397.7-06:629.78

EFFECT OF VARIABLE INFRALOW-FREQUENCY MAGNETIC FIELD ON DEVELOPMENT OF HYPERLIPIDEMIA IN HYPOKINETIC RATS

[Synopsis of article by Ye. V. Yevstaf'yeva, N. A. Temur'yants, A. M. Stashkov and V. B. Makeyev]

[Text] Studies were made of the effects of variable magnetic fields (VMF) of infralow frequency (ILF) on development of one of the important signs of hypokinesia, hyperlipidemia, in rats whose movements were restricted. The study was conducted on 220 mongrel white rats (males) weighing 170-180 g. The animals were divided into four groups. The first group consisted of animals (control) kept under the usual vivarium conditions, the second were rats under analogous conditions but exposed daily for 3 h to VMF at a frequency of 8 Hz and intensity of 4.1 A/m. The third and fourth groups of animals were put in cages that restricted their normal mobility, and the fourth group was submitted concurrently with the second to VMF of the above characteristics. Survival under hypokinetic conditions was 100%. On the 3d, 9th, 28th and 45th days of the experiment, 10-20 animals from each group were decapitated. We assayed blood serum total lipids (TL), total cholesterol (CS), CS content of α-lipoproteins (α-LP), β-lipoproteins (β-LP) and triglycerides (TG). The data were submitted to processing by methods of parametric and nonparametric statistics on a YeS-1020 computer. The results of this study revealed that, under hypokinetic conditions, the experimental animals developed hyperlipidemia, which is consistent with data in the literature. Maximum increase in CS and CS of α-LP was observed on the 9th day of hypokinesia. Thereafter, these parameters declined. The blood serum β-LP and TG levels in this group of animals rose progressively with increase in observation time. In rats exposed to hypokinesia and VMF there was also an increase in concentrations of the tested components of lipid metabolism in blood serum. However, at all tested times these changes were considerably less marked ($P<0.001$). Moreover, by the 45th day of the experiment, blood serum levels of CS, CS in α-LP and TL in this group were virtually comparable to control values. In intact animals, there was a tendency toward decline of CS, TG and β-LP in blood serum under the effect of 9-fold exposure to VMF. Thus, the results of this study warrant the belief that a weak ILF VMF limits development of hyperlipidemia in rats with a low level of motor activity. The described findings are easily reproducible and were confirmed in the next two series of experiments. It is necessary to pursue further investigations to study the mechanism of the observed phenomenon, since the established facts of beneficial physiological effect of VMF with the above-mentioned characteristics on some manifestations of the hypokinetic syndrome are of great theoretical and practical interest. 1 illustration, 10 references.

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INVESTIGATION OF SPATIAL-FREQUENCY FUNCTION OF THE HUMAN EYE AT HIGH AIR PRESSURE

[Synopsis of article by R. L. Boush, A. V. Vetyugov, S. M. Gvozdev and S. S. Romanov]

[Text] A study was made of the effect of high air pressure on spatial-frequency function (SFF) of the human eye. Sinusoid grids generated on the screen of a television receiver served as the test object. Using an optical system, the testing pattern was transmitted through a port into the pressure chamber. Monocular observation was made through a telescope in the pressure chamber. An 8.5×8.5° visual field was formed. Four average levels of test object brightness were used: 30, 3, 0.3 and 0.03 kD/m^2. The range of spatial frequencies was 0.025-1.9 $mrad^{-1}$. Contrast was changed smoothly from 0 to 0.6. Four pretrained people 21-23 years of age participated in the tests. At first, each of them adapted to the dark for 10-15 min, then was oriented for average brightness of background. Observation time was not limited. A series of measurements of threshold contrast consisted of 10 grid presentations at each spatial frequency. Experiments were conducted at the same time of day to reduce the influence of circadian fluctuations in contrast sensibility. One subject, who had participated in tests at normal atmospheric pressure also participated in those involving elevated air pressure. SFF was determined at two levels of brightness: 30 and 3 kD/m^2 at air pressure of 5.2 kG/cm^2. Isopressure time constituted 45-60 min, compression rate was 1 and 2 kG/cm^2/min. SFF obtained under normal conditions revealed that there is a decline of contrast sensibility at low spatial frequencies, and this decline is more significant for $\bar{L}$ = 3 kD/m^2. Maximum function is in the range of 0.2 to 0.5 $mrad^{-}$ and it shifts in the direction of higher spatial frequencies for high brightness levels. At high spatial frequencies there is drastic reduction of contrast sensibility, and at frequencies in excess of 1.5 $mrad^{-1}$ contrast sensibility decreases by a factor of 10^2. This is also where one observes marked dependence of visual acuity on brightness.

SFF of the eye was compared under normal conditions and at high air pressure. The results revealed that, after establishment of isopressure of 5.2 kG/cm^2, there was drastic worsening of eye characteristics tested, followed by slow (within 30 min) recovery. However, there was no complete restoration of spatial-frequency characteristics. The decline of contrast sensibility is manifested more at high spatial frequencies. An increase in compression rate extended SFF recovery time. This was associated with more severe worsening of characteristics in the first minutes of isopressure at higher compression rate. It is assumed that this may be related to nonuniform dynamic distribution of nitrogen in body tissues. The change in threshold characteristics of the human eye at high air temperature is indicative of change in visual information processing and possibility of errors in operator performance when exposed to high ambient pressure. 4 illustrations, 9 references.

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EFFECT OF STATIONARY MAGNETIC FIELDS ON GAS-TRANSPORT FUNCTION OF BLOOD

[Synopsis of article by G. V. Cherkasov]

[Text] An investigation was made of the effect of magnetic fields on gas-transport function of blood, which was assessed by oxygen capacity and oxygenation of arterial blood in the lungs. Two series of experiments were conducted involving 3-h exposure to a stationary magnetic field (SMF) with intensity of 0.4 T. In the first series, which was performed on 23 mongrel female rats weighing 240-270 g, determination was made of arterial blood oxygen and carbon dioxide content, oxygen capacity, hemoglobin content right after exposure. On the basis of oxygen content of arterial blood and oxygen capacity, oxygenation of arterial blood in the lungs was calculated. The second series of experiments was conducted on 20 male Wistar rats weighing 260-300 g. Determination was made of oxygen capacity and hemoglobin content. Concurrently, there were tests with a control group of animals in each series. The studies revealed that, in control animals, arterial blood contained 16.09±0.77 vol.% oxygen and 53.08±1.44 vol.% carbon dioxide. Blood oxygenation in the lungs constituted 85.80±3.12%. Under normal conditions, arterial blood oxygenation constitutes 94-98%. Evidently, inadequate oxygenation was due to diminished pulmonary ventilation because of the anesthesia. Hemoglobin content in control animals of different series ranged from 15.16±0.17 to 11.9±0.28 g%. For this reason, oxygen capacity was greater in the first series than the second, constituting 18.56±0.35 and 17.72±0.27 vol.%, respectively. The parameters studied did not undergo changes at the tested times after exposure to SMF. The gas composition of blood immediately after exposure did not differ from control values. Immediately after exposure to SMF and 1 day later, oxygen capacity of experimental animals' blood and hemoglobin level also corresponded to the control. Oxygenation of blood in the experimental group of animals was the same as in the control group, which was indicative of absence of disturbances in permeability of the air-blood barrier. Thus, these studies revealed that 3-h exposure of animals to SMF of 0.4 T does not affect gas-transport function of blood right after exposure or 1 day later. 2 tables, 4 references.

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